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APPARATUS FOR THE STERILIZATION OF WATER BY MEANS OF OZONE.*

By Dr. Gg. Erlwein.

That ozone is of practical utility in the sterilization of water has been demonstrated by the ozone water works of Paderborn. This installation has supplied the city day and night for the last three and a half years with potable water, and as a result typhoid fever has been practically eliminated, notwithstanding that in former times the city suffered from an epidemic of this disease almost annually. However, not alone in centralized water supply works of this character, but in separate individual installations as well, ozone sterilization is possible of practical utility. In addition to purposes of purely scientific investigation in the bacteriologic-hygienic institutions, ozone has recently been successfully employed in the sterilization of water in small stationary communal and industrial installations, as well as for military purposes in sup-

* Translated for the Scientific American Supplement from Gesundheit of February 1, 1906.

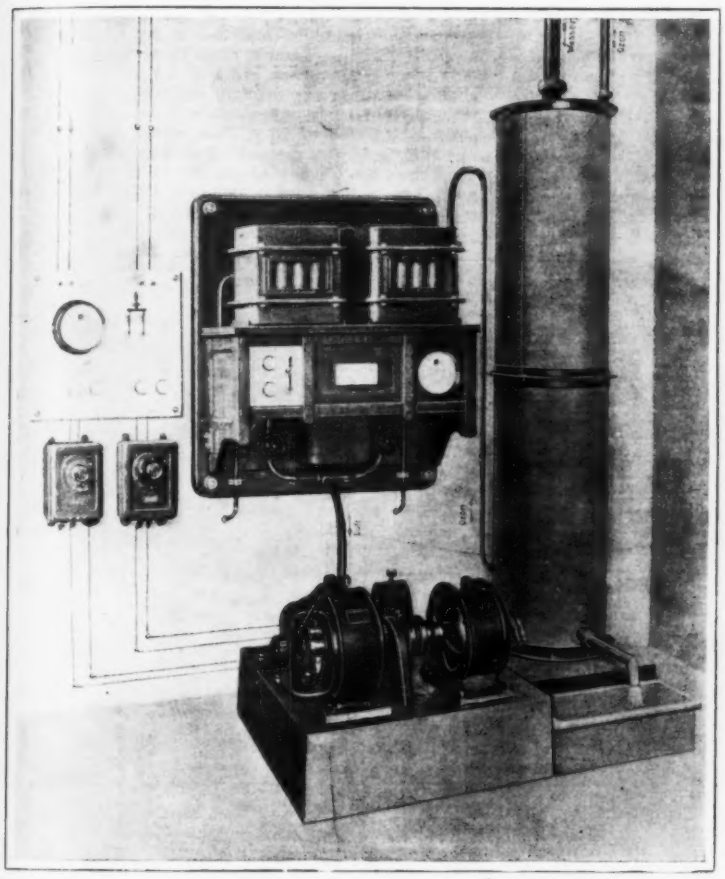


FIG. 3.—STERILIZING OUTFIT FOR SMALL COMMUNITIES OR FACTORIES.

FIG. 6.—MILITARY INSTALLATION IN OPERATION IN MANCHURIA DURING THE LATE WAR.

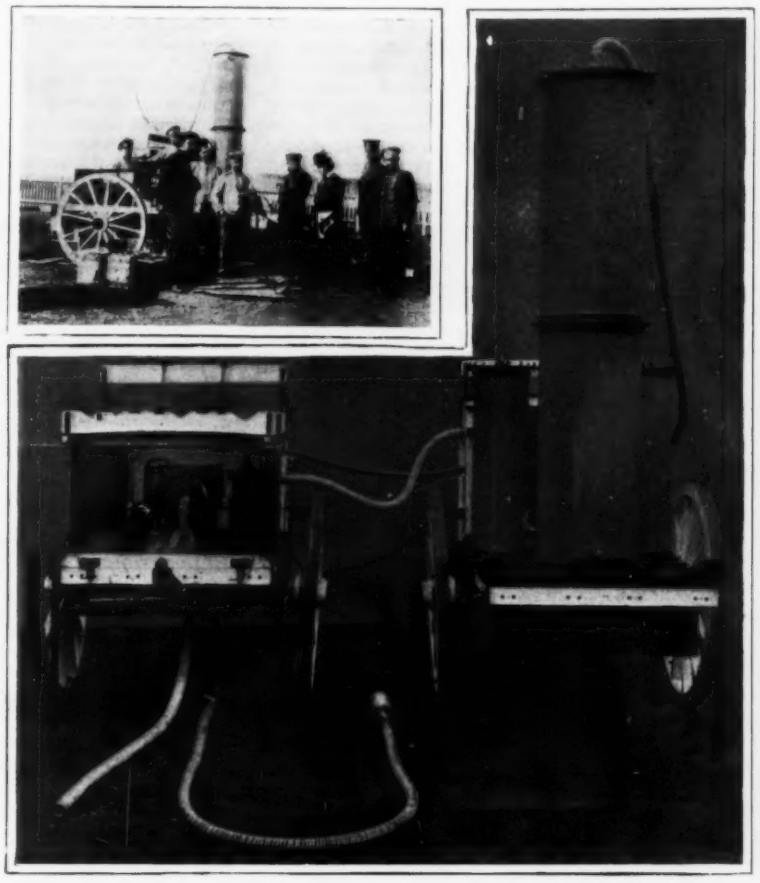


FIG. 4.—PORTABLE MILITARY OUTFIT READY FOR OPERATION.

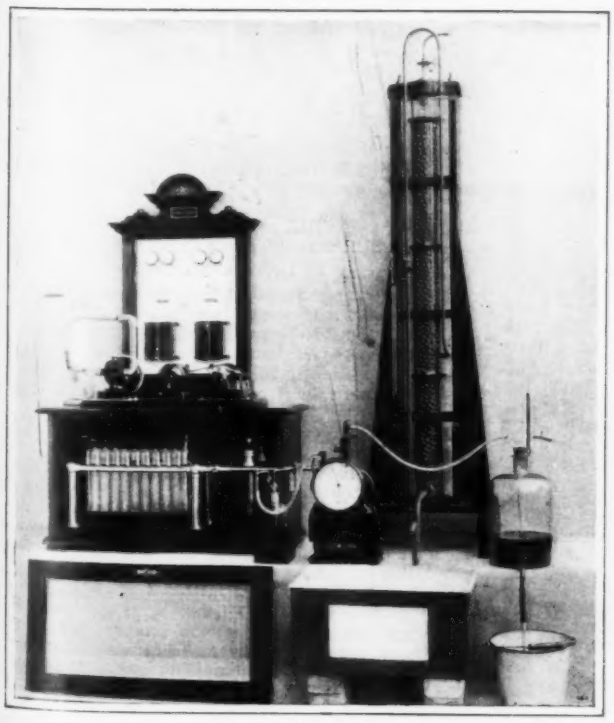


FIG. 1.—STERILIZATION OUTFIT FOR PURPOSES OF SCIENTIFIC INVESTIGATION.

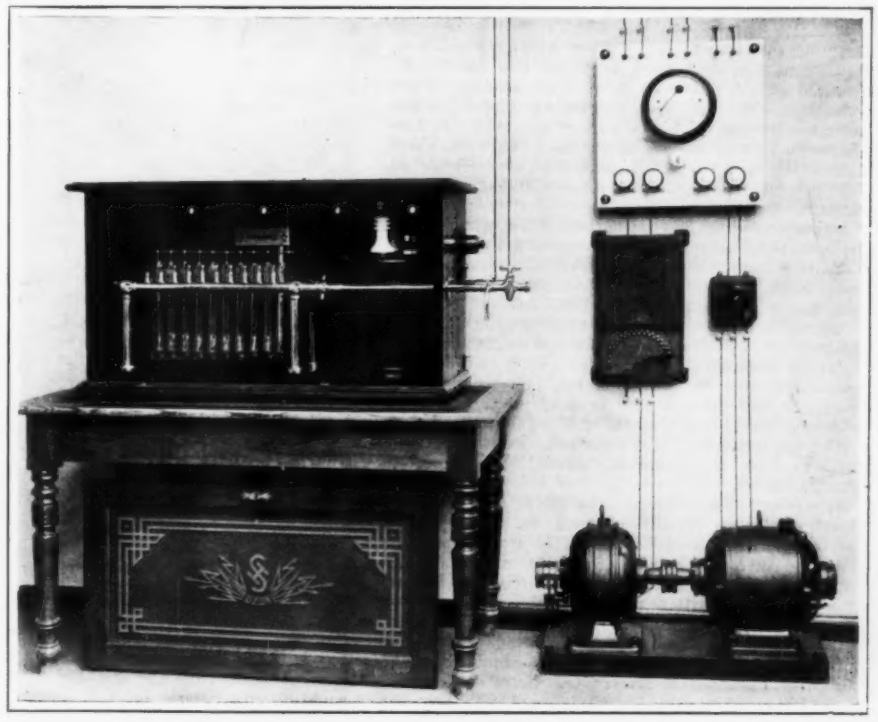


FIG. 2.—INSTALLATION WHICH UTILIZES ALTERNATING-CURRENT SUPPLY.

APPARATUS FOR THE STERILIZATION OF WATER BY MEANS OF OZONE

plying troops in the field. With these uses in view the firm of Siemens & Halske, of Berlin, has constructed a variety of apparatus for ozone sterilization, including outfits for experimental scientific work, for the production of sterile water for drinking or other uses in small communities, and for the purposes of certain industries, and for portable military service for troops in the field or on station.

The sterilization outfit for scientific purposes, as it has been installed in several institutions, can be connected to a direct-current circuit, like an ordinary incandescent lamp. As shown in Fig. 1, it consists of a glass sterilizing column about five feet high, an ozone apparatus mounted in and upon a wooden casing, and a device between these first two for the quantitative determination of the ozone. The column, which has water inlet and exit at the top and bottom respectively, is filled with small glass, clay, or porcelain balls, and is provided with a measuring tube having a throttling valve and a differential gage. By means of this measuring tube, which is included in the ozone air circuit, it is possible at all times to determine exactly the quantity of the ozone passing through the column, a standardized table being used in this connection.

The apparatus inside the wooden case consists of a ten-piece Siemens glass tube ozone outfit, and a transformer, while on the top of the box is located a small direct-current motor, which is connected on one side by cord pulleys to a small blower, for the purpose of forcing the air through the ozone apparatus, and on the other side to a rotating circuit-breaker, which produces the interrupted direct current for the primary circuit of the transformer. Upon the box there is, besides, a wash bottle employed for the drying of the air by means of sulphuric acid or calcium chloride. Behind the case is a vertical switchboard, upon which are located two single or double switches, and two regulating resistances for the direct-current motor circuit, and the interrupter direct-current circuit of the primary of the transformer. The ozone apparatus includes ten Siemens ozone tubes of the older type, mounted side by side. Each of these consists of two concentric glass cylinders, one within the other and fused together at the top, the outer one placed in cooling water, while the inner one is filled with water. This water is utilized as a conductor of the high-tension current to the discharge poles of the ozone apparatus.

As means for the determination of the ozone during the operation, the following apparatus are arranged in series in a side conduit, which branches from the main ozone circuit between the column and the ozone apparatus: A glass bottle filled with a solution of iodide of potassium, and provided with a mercury seal for the purposes of ozone absorption and titration; a gas meter to measure the ozone air; and a suction flask operated by the outflow of water, and which, when graduated, can also be used in place of the meter to determine the amount of the gas. The suction flask can be dispensed with if the gas pressure is sufficiently great to force the ozone air through the potassium iodide solution.

In starting the apparatus, the motor circuit is first closed, and when the interrupter is rotating properly, the transformer circuit is closed; in stopping the installation this proceeding is reversed, and the transformer circuit and then the motor circuit are opened by means of the switches shown in the photograph on the switchboard.

If local electrical and other conditions permit the operation of the ozone apparatus by means of alternating current instead of interrupted direct current, the construction shown in Fig. 2 is used. In this the current utilized in the transformer is supplied by a small D.C.-A.C. converter, that is by an A.C. machine (Fig. 2, on the left) which is coupled to a D.C. motor of about one-half horse-power in circuit with the main supply. A laboratory installation of the above described form, and which can be regulated for all practical circuit tensions, requires from one-quarter to one-half horse-power according to the current selected, and furnishes, when atmospheric oxygen in the form of dry air is used, and the rate of flow is 130 to 260 gallons per hour, from 5 to 6 grammes of highly concentrated ozone, measured by introduction into a slightly acid solution of potassium iodide. If pure oxygen is used instead of air, the output, depending upon the rate of flow, is two to three times as great.

The stationary ozone installation for smaller quantities of water, say a production of 800 to 2,500 gallons per hour, of the type used in St. Petersburg for drinking water, in Astrakhan for mineral water, and in a large brewery of Munich for sterilizing the water used to wash certain vessels, is represented in Fig. 3. From right to left in the photograph, the apparatus consists of a scrubber-like sterilizing cylinder of the usual form and filled with pebbles, of a bed-plate on the floor upon which are located a D.C. motor and coupled thereto an A.C. generator, the motor driving a water pump by means of belts or chains, a wall bracket upon which are located two Siemens ozone chambers (each containing eight ozone tubes) an electric measuring instrument, and a switch for the primary circuit of the transformer. Besides these there are the transformer and the switchboard with switches, voltmeter, and resistances for the motor and for the exciting circuit of the A.C. machine. The ozone tubes have inner poles in the form of aluminium cylinders, which are not grounded, and outer poles surrounded by cooling water. The arrows on the illustration show the direction of flow of the air and the water in the entire installation, as well as in the ozone apparatus and the sterilizing column. Outfits of this class are provided with the safety appliances common to all the Siemens ozone apparatus. These devices automatically cut off the flow of feed water to the column when the voltage in the apparatus decreases, or ceases entirely, or when the stream of ozonized air passing through the sterilizing column falls below a certain limit.

The portable sterilization outfits for military use are shown in Figs. 4, 5, and 6, which represent a type employed by the Russian army in Manchuria, and which has been considered by other governments for the supplying of water for fortifications, or for use as portable reserves in case of epidemics due to impure water in military camps. A military installation of this class—other outfits constructively simpler have been designed—consists of two wagons, a machine and a sterilizing vehicle. Upon the machine wagon are located all motor parts, while the other carrier bears all the sterilizing portions of the apparatus. The first mentioned carries a gasoline motor of the usual automobile type, direct-coupled to the shaft of this an A.C. dynamo with a D.C. exciting generator for supplying low-tension primary A.C. current to the transformer, a small chain-driven rotary water pump, which draws the feed water from the supply and forces it into the sterilizing column, a small blower to supply the air (which is previously dried to a certain extent by passing through calcium chloride) for the ozone apparatus and the column of the sterilizing wagon, two cases of reserve ozone tubes, and extra parts for the gasoline motor.

On the sterilizing vehicle are two spring-supported Siemens ozone cases (one of these being in reserve), with eight ozone tube elements, a transformer under the ozone apparatus for the production of the high-tension from the low-tension primary A.C. current supplied by cable from the machine wagon, three parallel rapid filters consisting of metal cylinders in which are hung closed filter bags, through which the feed water is forced before it is introduced into the column, and is thereby freed of larger suspended impurities, and a cylindrical metal sterilizing column about eight feet high filled with pebbles or pieces of cement-covered pumice stone approximately the size of pigeon eggs. The column consists of two parts, each with a perforated base, placed one upon the other, and, to permit the easy taking apart of these sections, joined by means of bolts. This vehicle also carries several cases for tools and extra parts of various kinds.

In operation the wagons, as shown in Fig. 4, usually stand side by side. By means of the heavy suction and force hose, the feed water is introduced into the rapid filter and the sterilizing column by the pump on the machine wagon. By means of the smaller air tube, the air is forced by the blower into the ozone apparatus and thence into the lower part of the sterilizing column, while the primary current from the A.C. dynamo is led to the transformer of the sterilizing wagon by the cable, also visible in the illustration. Fig. 5 shows the apparatus properly packed upon the two carriers for transportation. The column is shown in two parts upon the sterilizing wagon, while on the machine wagon are the three rapid filters. Each vehicle is intended to be drawn by one horse, and weighs about 2,000 pounds.

The installation is designed for a production of 500 to 800 gallons of water per hour per wagon, and its operation requires about 2 horse-power. It works without circulation of the ozone air current. As a matter of precaution, the ozone is produced in a quantity so much greater than that really necessary, that even if the supply water is of an extremely bad quality, only about one-third to one-half the amount of ozone generated is actually required for the sterilization.

Before the outfit was sent to Russia its sterilizing effect was tested by Prof. Proskauer, of the Institute for Infectious Diseases (Koch), and these investigations thoroughly corroborated the bactericidal effect of water ozonization. In St. Petersburg four wagons were tested for their sterilizing qualities—using bacterially-contaminated water of the Neva—as well as for stability of operation, by the hygienic and bacteriologic expert, K. Kressling, of the Royal Laboratory of St. Petersburg, and by a military commission, with the result that immediately afterward the wagons were forwarded to the seat of war in Manchuria. Fig. 6 shows one of these Russian outfits in operation in one of the great military camps at Harbin, during the past Russo-Japanese war.

FIG. 5.—MILITARY OUTFIT PACKED UPON ITS WAGONS FOR TRANSPORTATION.

APPARATUS FOR THE STERILIZATION OF WATER BY MEANS OF OZONE.

HISTORY OF THE STANDARD WEIGHTS AND MEASURES OF THE UNITED STATES.*

By LOUIS A. FISCHER.

THE subject of weights and measures is one of such great interest and importance and is attracting so much attention in this country and in England at the present time that a short account of the steps taken to secure uniformity in the United States is deemed an appropriate subject to bring to the attention of this convention.

The attention of the United States government has long been directed toward securing uniformity in this country, and in the effort to secure international agreement in weights and measures it has always shown the greatest interest. The history of the original Confederation of States, and of the constitutional government of the United States, is full of evidences of the perplexities arising from the diversity of weights and measures throughout their jurisdiction, and of the desirability of a uniform system.

The weights and measures in common use in this country at the time of the American Revolution were all of English origin, and were in use in England at that period. The principal units were the yard, the avoirdupois pound, the gallon, and the bushel. More or less authentic copies of the English standards of

* An address delivered before the First Annual Meeting of the Sealers of Weights and Measures of the United States at the Bureau of Standards, Washington, D. C., 1905.

the denominations mentioned had been brought over from time to time and adopted by the different colonies. Divergencies in these weights and measures were, however, quite common, due, no doubt, to the fact that the system of weights and measures of England was not itself well established, and hence the copies brought to this country were often adjusted to different standards.

That this condition was recognized very early is made evident by the Articles of Confederation which contained the following clause: "The United States in Congress assembled shall also have the sole and exclusive right and power of regulating the alloy and value of coin struck by their own authority, or by that of the respective States—fixing the standard of weights and measures throughout the United States." This power was transferred to Congress by the Constitution of the United States in Article I., Section 8, the language being as follows: "The Congress shall have Power . . . to coin Money, regulate the Value thereof, and of foreign Coin, and fix the Standard of Weights and Measures."

While Congress was not slow to take action in regard to coinage, it seems not to have been inclined to come to a decision in regard to weights and measures, though apparently willing enough to consider the subject. Washington, in his first annual message to Congress, January, 1790,[1] stated that "uniformity in the currency, weights, and measures of the United States is an object of great importance, and will, I am persuaded, be duly attended to." In accordance with Washington's suggestion, the matter was referred to a select committee of the House of Representatives, with instructions to prepare a bill, and it was also ordered that the matter be referred to the Secretary of State to prepare and report to the House a proper plan for establishing uniformity in the weights and measures.[2] Jefferson was then Secretary of State, and in response to the above request made a report, in which he proposed two distinct plans. The first was substantially to "define and render uniform and stable the existing system . . . to reduce the dry and liquid measures to corresponding capacities by establishing a single gallon of 270 cubic inches and a bushel of eight gallons, or 2,160 cubic inches . . ." The second plan was "to reduce every branch to the same decimal ratio already established for coin, and thus bring the calculations of the principal affairs of life within the arithmetic of every man who can multiply and divide plain numbers."[3]

No action was taken, however, by the House, and in his second message to Congress, on December 8, 1790, Washington again called the attention of that body to the importance of the subject.[4] A few days later the House ordered that the report of Jefferson, referred to above, be communicated to the Senate. On March 1, 1791, the Senate committee to which the matter had been referred reported that it would not be eligible to make a change in the weights and measures, as a proposition had been made to the French and British governments to obtain an international standard.[5] This report was accepted and the matter rested there, although Washington, on October 25, 1791, repeated his former recommendations in his third annual message to Congress, in the following language:[6]

"A uniformity in the weights and measures of the country is among the important objects submitted to you by the Constitution, and if it can be derived from a standard at once invariable and universal, must be no less honorable to the public councils than conducive to the public convenience."

A week later the Senate appointed a committee to take into consideration the subject of weights and measures. The committee reported on April 4, 1792, recommending the adoption of the second plan proposed by Jefferson, which was an entirely decimal system. Again no definite action was taken. The matter was considered in a desultory way by Congress from time to time, but no agreement was reached, notwithstanding that the repeated recommendations of Washington were followed by those of Adams. A sufficient explanation for the disinclination of Congress was the difficulty of agreeing upon a plan.

The Fifth Congress, second session, in 1799, passed an act ordering that the surveyor (of each port of the United States) shall from time to time, and particularly on the first Monday of January and July in each year, examine and try the weights, measures, and other instruments used in ascertaining the duties on imports with standards to be provided by each collector at the public expense for that purpose; and when disagreements and errors are discovered he shall report the same to the collector and obey and execute such directions as he may receive for the correction thereof, agreeably to the standards aforesaid.[7]

This was the first act passed by Congress in regard to weights and measures, but in view of the fact that no standards had ever been adopted, the legislation was not put into operation until about thirty-five years after its passage, when certain standards, which will be referred to later, were adopted by the Treasury Department.

After the war of 1812, the question of uniformity in weights and measures was again brought to the attention of Congress, and in 1819 a committee of the House of Representatives proposed to adopt absolute standards conforming to the weights and measures in common use; to obtain through a commission copies of the yard, the bushel, the wine gallon, and the pound supposed to conform to those in common use in the United States; to preserve these standards and to distribute copies of them; to compare the length measure with the length of the seconds pendulum, and also with that of an arc of the terrestrial meridian; to connect them by determining the weight of a certain bulk of distilled water, and to define the bushel and the gallon by the weight of water which they contain.[8] No further record of the report is found, and it may be assumed that no action upon it was taken. The Senate had, by a resolution adopted March 3, 1817—two years prior to the above report—requested the Secretary of State to prepare and report a "statement" relative to the regulations and standards for weights and measures in the several States and relative to the proceedings in foreign countries for establishing uniformity in weights and measures, together with such propositions relative thereto as might be proper to adopt in the United States.

John Quincy Adams was at that time Secretary of State, and four years later—namely, on February 22, 1821—he submitted an elaborate report to the House of Representatives, in which, among other recommendations, the following are found:

(1) To fix the standard with the partial uniformity of which it is susceptible for the present, excluding all innovations.

(2) To consult with foreign nations for the future and ultimate establishment of universal and permanent uniformity.

As before, Congress took no action, probably because the situation at that time was extremely complicated. Neither the metric system in France nor the system in common use in England was well established. In France the law making the metric system compulsory had been repealed, and the metric system was in use side by side with the ancient weights and measures, thus producing endless confusion. In England the situation was not much better; the ale gallon of 282 cubic inches, and the wine gallon of 231 cubic inches, were both in use until 1824, when the new imperial gallon, containing 10 pounds of water, and of a capacity of about 277¼ cubic inches, was adopted, together with the bushel of 8 gallons. Neither of these measures was in use in this country, and hence the United States could not at that time adopt either the system in use in England or the one in France without introducing radical changes in the weights and measures already in use, nor was there at that time any positive assurance that either the English or the metric system would be permanent.

While Congress had been considering the matter, most of the States had, independently of one another, secured and adopted standards. Most of the standards thus adopted were brought from England; nevertheless, standards of the same denominations differed widely among themselves, thus perpetuating confusion in the commerce between adjacent States.

Though confusion in commercial transactions might be overlooked, uncertainty in regard to the coinage could not be tolerated, and on May 19, 1828, a certain troy pound was adopted as the standard for coinage by Congress in an "Act to continue the Mint at the City of Philadelphia, and for other purposes." The section 2 of the act referred to reads as follows:

"And be it further enacted, That, for the purpose of securing a due conformity in weight of the coins of the United States . . . the brass troy-pound weight procured by the minister of the United States at London, in the year one thousand eight hundred and twenty-seven, for the use of the mint, and now in the custody of the Mint at Philadelphia, shall be the standard troy pound of the Mint of the United States, conformably to which the coinage thereof shall be regulated."

The troy pound thus adopted had been procured in the year 1827 by Albert Gallatin, minister of the United States at London, and brought to this country by special messenger, who delivered it to the director of the Mint at Philadelphia. The weight was of brass and an exact copy of the imperial troy pound of Great Britain, according to the statement of Capt. Kater, who made the comparison between the two standards. The casket and accompanying packages were retained under seal until Mr. Adams, President of the United States, visited Philadelphia and verified the seal of Mr. Gallatin, and the other facts in regard to its authenticity.

This ceremony took place on October 12, 1827, and the full certificate of President Adams in regard to the seal, which he readily recognized, and to the whole transaction and consequent accuracy of the weight was added to the vouchers in the case. He declared, in conclusion, his belief that the brass weight then exhibited was the identical pound copy of the imperial standard troy pound of Great Britain referred to in the aforesaid certificates.[9] The foregoing facts were communicated to Congress through the Committee on the Mint, and resulted in the passage of the act cited above.

While the act of Congress of 1828 only made this pound the standard for coinage, it virtually became the fundamental standard of the United States from which the avoirdupois pound in common use was derived.

On May 29, 1830, two years after the mint pound had been legalized for coinage, the Senate passed a resolution directing the Secretary of the Treasury to cause a comparison of the weights and measures in use at the principal custom-houses to be made, and to report to the Senate at its next session.

Steps were promptly taken by the Treasury Department to comply with the resolution of the Senate, and the preliminary report of F. R. Hassler, superintendent of the Coast Survey, to whom the investigation had been intrusted, was transmitted to the Senate on March 3, 1831,[10] this being followed by a more complete report in June, 1832.

As was anticipated, large discrepancies were found to exist among the weights and measures in use at the different ports, some being too small and others too large, but the average value of the various denominations agreed fairly well with the weights and measures in use in Great Britain at the time of the American Revolution.

Without waiting for authority from Congress the Treasury Department took immediate steps to correct the evil by having constructed, under the direction of Mr. Hassler, the necessary weights and measures for the customs service. The divergencies among the weights and measures in use in the customs service were directly opposed to the spirit of the Constitution, which requires that all duties, imposts, and excises shall be uniform throughout the United States,[11] and the Secretary of the Treasury felt fully authorized in taking steps to secure uniformity when discrepancies were once known to exist.

Before weights and measures could be constructed, however, it was necessary for the Treasury Department to determine upon certain units, and to adopt material representatives of these units. Those finally adopted were the yard of 36 inches, the avoirdupois pound of 7,000 grains, the gallon of 231 cubic inches, and the bushel of 2,150.42 cubic inches. The standard yard adopted was the 36 inches comprised between the twenty-seventh and sixty-third inches of a certain 82-inch brass bar, prepared for the Coast Survey by Troughton, of London. This bar had been brought to the United States by Hassler in 1813, and the 36-inch space referred to was supposed to be identical with the English standard at 62 deg. F., though it had never been directly compared with that standard.

It is evident from the reports of Mr. Hassler that he regarded the English yard as the real standard of length of the United States, and the Troughton scale merely as a copy whose length should be corrected if it was subsequently found to differ from the English yard; and this view was taken by those who subsequently had charge of our standards, as will be shown later on.

The avoirdupois pound adopted by Mr. Hassler as the standard for the Treasury Department was derived from the troy pound of the mint according to the equivalent, 1 avoirdupois pound equals 7000/5760 pounds troy. This was the accepted relation in this country as well as in England; hence both the troy and avoirdupois pounds adopted were in practical accord with the similar standards of Great Britain.

(To be continued.)

[1] Messages and Papers of the Presidents, 1, p. 66.
[2] Congressional Register, 3, p. 106.
[3] Journal of the H. R., Childs & Swaine, p. 106.
[4] Messages and Papers of the Presidents, 1, p. 83.
[5] Journal of the Senate, p. 143; John L. Fenno.
[6] Messages and Papers of the Presidents, 1, p. 108.
[7] Statutes at Large, 1, p. 643.
[8] Executive Doc. No. 73, 30th Cong., 1st sess., Senate.
[9] Report on Weights and Measures, Franklin Institute, 1834, Appendix No. VII.
[10] See H. R. Doc. No. 299, 22d Cong., 1st sess.
[11] Sec. VIII, clause 1.

EARLY MAPS.

IT is interesting to look back and see the gradual progress of the delineation of the world and to mark how very recent any approach to accuracy is.

The very earliest maps of any extent of country are unfortunately lost to us. The first man who made a map of which any historical record exists is Anaximander of Miletus, about 600 B. C., but we know nothing of it. A map is mentioned by Herodotus as having been taken in 500 B. C. by Aristagoras of Miletus in the shape of an engraved bronze plate whereon the whole circuit of the earth was engraved, with all its seas and rivers, to influence Cleomenes, King of Sparta, to aid the Ionians against Persia. This was probably the work of Hecatæus, to whom early geography owed much. His works are also only known to us by quotation; but they are especially interesting as containing an early idea of the limits of Africa, which he represents as entirely surrounded by the sea—a circumstance apparently either forgotten or disbelieved in later years.

Eratosthenes, 250 B. C., and Hipparchus, 150 B. C., made great advances, and the former made the first attempt to measure the size of the earth by the difference of latitudes between Assouan and Alexandria in Egypt, an attempt which, considering the great imperfection of his means, was remarkably successful, as, assuming that we are right in the length of the stadium he used, he made the circumference of the globe 25,000 geographical miles, whereas it should be 21,600.

He also devised the system of meridians and parallels as we now have them; but the terms "latitude" and "longitude," to denote positions on those circles, were introduced by Ptolemy.

The maps of Ptolemy, the great Alexandrian astronomer and geographer of A. D. 150, are the earliest we possess. He drew, besides a general map of the whole known world from the southern part of the Baltic to the Gulf of Guinea, north and south, and from the Canary Islands to the China Sea, east and west, a series of twenty-six maps of the different parts.

Ptolemy's maps and his method of representing the globe on a flat surface had a great influence on geography for many years. After his time the Greek civilization waned, and the general decline of the Roman Empire, followed by its disruption by the invasion of barbarians, closed the course of discovery in all

branches of research for centuries. It is not too much to say that for 1,300 years no advance was made, and until the commencement of exploration by sea, which accompanied the general revival of learning in the fifteenth century, Ptolemy's maps represented the knowledge of the world.

As might be expected, the further he got from the Mediterranean, the greater were his errors; and his representations of eastern Asia and northwestern Europe are somewhat grotesque, though quite recognizable in the main.

Of Africa south of the equator he knows nothing, and his map of it terminates with the border.

RESERVOIR, FOUNTAIN, AND STYLOGRAPHIC PENS.—I.*

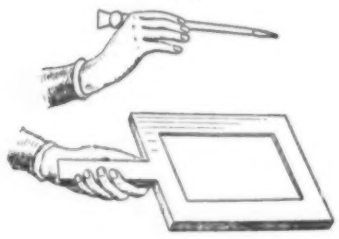
By JAMES P. MAGINNIS, A.M.Inst.C.E., M.Inst.Mech.E.

ANCIENT WRITING IMPLEMENTS.

THERE does not appear to exist, except on the shelves of the Patent Office, any systematic record of what has been done to produce the elegant and perfect writing instrument of to-day, known as the "fountain pen."

It is probably to many unknown history, but on the other hand, a large number of persons must be well acquainted with what has been done in the past to perfect the writing implements which have become so familiar to all; for in these days of advancement it would be difficult to find anyone incapable of using a pen.

FIG. 1.



Many inventors, and some of these of the first rank, have devoted much time and ingenuity to the subject, with the object of producing a reliable instrument.

It will perhaps astonish some of my readers when I refer to early inventions, as there is a general belief that fountain pens are of quite modern date.

The time at my disposal will not permit of a complete reference, but I shall endeavor, by short description, drawings, and photographs, to present most of the leading types, more or less in detail, and I have been enabled, to a great extent, to do this by the generous assistance of leading manufacturers in England, the United States, and elsewhere, who have readily placed valuable information at my disposal for the purposes of these papers.

It is necessary to emphasize the fact, that I merely speak as an outsider, a man in the street, from the unbiased standpoint of one who finds recreation and instruction in endeavoring to ascertain the why and the wherefore of articles of utility. I have, therefore, no ax to grind, unless it be to call the attention of the younger members among my readers to the pleasure to be derived from the occupation of tracing the history of inventions.

To trace the history of fountain pens, is the primary objective I have in view, but I think that a hasty *resumé* describing the growth of writing implements generally from early days would perhaps make the subject a little less prosaic, and to some extent reduce the result of my research to something more interesting than a mere catalogue of inventions, however instructive such a catalogue might be.

In D'Israeli's "Curiosities of Literature" we read: "When men had not yet discovered the art of recording events by writing, they planted trees, or they erected rude altars, or heaps of stones as remembrances of past events." And again: "Hercules probably could not write when he fixed his famous pillars."

Stylus and Tabula.—As long as people wrote upon tablets covered with wax, they were obliged to use a style or bodkin, made of bone, metal, or some other hard substance. A curious drawing in a fine manuscript, once the property of Charlemagne, and now preserved in the public library of the ancient city of Treves, on the Moselle, furnishes the illustration (Fig. 1) here shown, of a tabula held by a handle in the left hand of the scribe, exactly resembling the old horn book of our village schools. The surface is covered with wax, to be inscribed by the metal style held in the right hand. These styli were sometimes surmounted by a knob, but frequently were beaten out into a broad flat eraser used to press down and prepare the waxen surface for a new inscription. The stylus here shown illustrates both knob and eraser, or burnisher. (Fig. 2.)

When it became usual to write with colored liquids, scribes employed a reed, and later, quills or feathers. It is rather astonishing that there is no authentic record as to the precise kind of reeds the ancients used for writing, though writers mention the places where they grew wild, and where it is highly probable they grow still. It is, however, reasonable to suppose that the same reeds are used even at the present time by all the Oriental nations, for it is well known that among the people of the East old manners and instruments are not easily banished by new modes and new inventions.

Reed Pen.—Most authors who have discussed the history of writing have contented themselves with informing us that "a reed was employed," but the genus of grasses called by the ancients "calamus" and "arundo," is more numerous in species than the genus of grasses to which their corn belonged. A writer—Chardin—speaks of the reeds which grow in the marshes of Persia, and which are sold and much sought after in the Levant, particularly for writing. Chardin says, "Their writing pens are made of reeds, or small, hard canes of the size of the largest swan quills, which they cut and slice in the same manner as we do quills, but they give a much longer nib." These canes or reeds are collected along the Persian Gulf, in a large fen. They are cut in the month of March, and when gathered are tied up in bundles and buried for six months, when they harden and assume a beautiful polish and color—a mixture of black and yellow. None of these reeds—Chardin says—are collected in any other place. As, he says, they make the best writing pens, they are transported throughout the whole East.

Although the reeds were split and formed to a point like our quills (Fig. 3), it certainly was not possible to make such clean and fine strokes, nor to write so long and so conveniently with them, as one can with quills. The use of them, however, was not entirely abandoned when people began to write with quills, which in every country can be procured from a bird extremely useful in many other respects. Had the ancients been acquainted with the art of employing goose-quills for this purpose, they would undoubtedly have dedicated to Minerva, not the owl, but the goose.

A writer in the fifth century states that Theodoric, King of the Ostrogoths, was so illiterate and stupid that during the ten years of his reign he was not able to learn to write four letters at the bottom of his edicts. For this reason the four necessary letters were cut for him in a plate of gold, and the plate being laid upon paper formed a stencil from which he is said to have traced the characters with a quill.

This account is not improbable, for history tells us that almost about the time of Theodoric, the Western Empire was governed by the Emperor Justin, who also could not write, and who used, in a like manner, a piece of wood having letters cut in it, but in tracing them out he caused his hand to be guided by one of his secretaries.

The English word "pen," the French "plume," and the German "feder" all signify the same thing, a "wing feather." There are many traces that quills were used as writing instruments by the ancient Romans. Perhaps the earliest specific allusion to the quill occurs in the writing of St. Isidore, of Seville, early in the seventh century.

For a long time goose quills were solely used, but afterward the wing feathers of swans, turkeys, peacocks, and crows were requisitioned. The goose quill was until 1830 almost the only kind of pen in general use, but it must not be supposed that pens made of various metals did not exist many years previous to 1830.

It is recorded that the Patriarchs of Constantinople, under the Greek Empire, were accustomed to sign their allocutions with tubular pens of silver, similar in shape to the reed pens, which are still used by the Oriental nations. The Chinese and Japanese, however, write with a brush or hair pencil dipped in Indian ink.

Other writers of the seventh century refer to quills in a vague manner, and it is not quite clear whether feathers or reeds are meant. Men of letters, well versed in such matters, assure us, from comparison of manuscripts, that writing reeds were used along with quills in the eighth century, at least in France, and that quills first began to be common in the ninth century.

In convents, it is said, reeds were retained for the writing of texts and initials of manuscripts, while for small writing, quills were everywhere employed. This statement must be taken with reserve, as it is probable that scribes and copyists would at first endeavor to write with quills in the same style as had been the custom when using reed pens, in order that the results might not seem very different from the then usual style. And with quills one can produce writing both coarse and fine. About the year 1433 writing quills were so scarce in Venice, that it was with great difficulty men of letters could procure them.

Inkhorn and Penner.—The scribes of the Middle Ages frequently carried their writing implements appended to their girdles, consisting of an inkpot and a case for pens. The latter was usually formed of leather softened by hot water, and then impressed with ornament, and hardened by baking. This was as strong as horn, of which substance the inkpot, or inkhorn, was generally made.

An engraved brass to the memory of a notary of the time of Edward VI., placed in a church at Ipswich, represents a penner and ink-horn slung across the man's girdle. They are held together by cords which slip freely through loops at the side of each implement, the knob and tassel at each end preventing them from falling.

Writing Table of a Scribe.—With the invention of the printing press the very laborious process of producing books by handwriting vanished for ever. Imagine the working table of a scribe, contemporary with the invention of the printing press, as depicted in a picture in the gallery of a museum in Naples. The pages upon which he is at work lie upon the sloping desk. In the table beyond he has stuck his penknife.

FIG. 4.

FIG. 5.

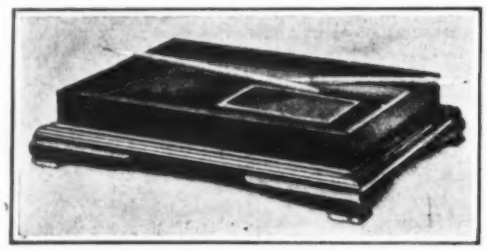


FIG. 6.

FIG. 7.

FIG. 2.

ANCIENT ROMAN STYLUS.

FIG. 3.

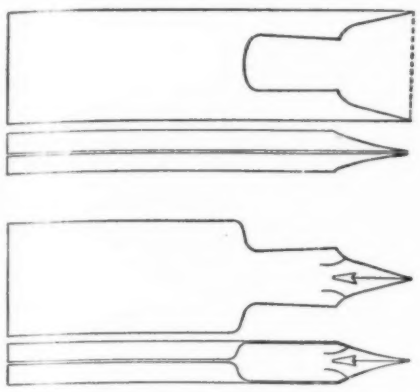
REED PEN—AS STILL USED IN THE EAST.

* Journal of the Society of Arts.

The pens lie on the standish in front of him. Bottles of ink of both red and black colors are also there, and an hour glass is at hand to give him due note of time, not necessarily because he was in any particular hurry, for they seemed to have plenty of time in those days. A pair of scissors and a case for a magnifying glass to assist his sight, are also within easy reach.

Eastern Writing Implements.—Another such picture

FIG. 8.



shows the writing materials and implements as used even to-day in Palestine. The scribes do not carry the genuine inkhorn nowadays, as did the prophets of old, but instead they have an apparatus consisting of a metal or ebony tube for reed pens, with a cup or bulb of the same material attached to the upper end to contain the ink. This tube they thrust through the girdle and carry with them at all times as we carry our pencils or fountain pens, always ready for use.

Brass Reed Tube and Ink Bulb.—I am indebted to my friend Mr. A. Hervé Browning for kindly affording me the opportunity to use this illustration. Mr. Browning lent me the original from which Fig. 4 has been photographed. It is an actual example of one of these tubes and inkpots, which was mentioned in the last paragraph. It is made of brass, and is richly carved all over its surface. The ink used in it was of a semi-fluid consistency, and in order to prevent its flowing from the ink bulb a piece of sponge was inserted.

Portable Ink Bottle.—Many will remember the general use, not a great many years ago, of a glass bottle so formed as to be safely carried with its neck inserted in the button-hole of a coat, and it will be evident to most that it forms a survival of the inkhorn.

Japanese Writing Box.—Here, in Fig. 5, is an interesting photograph of the writing box as used to-day by the Japanese, at home and in business. In the center of the box is a slab or palette of stone, formed with a sloping surface, becoming gradually deeper, till a well is formed at the further end. A supply of water is kept in the little bronze vessel seen beyond. When ink is required, a little water is poured on the slab, and Chinese or Indian ink is rubbed upon it till of the right consistency, just as engineers and architects rub up Indian ink for the preparation of drawings. The writer then fills one of the pens which you see in the box, and which are really brushes, and proceeds to make the wonderful marks which in his language represent words and sentences. The pens are made from the hair of deer, sable, or rabbit, fixed in reeds.

I may here say that I am indebted to Capt. Sparks, of Duke Street, Manchester Square, for the specimens of Japanese pens, and also to Messrs. Yamanaka, of New Bond Street, who very generously lent me this writing box as well as the following objects.

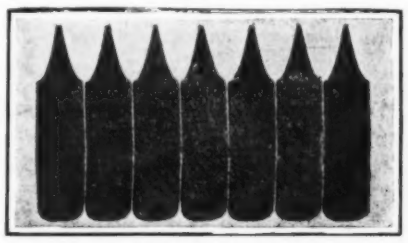
Japanese Pen Tube and Ink Box (Bronze).—Of course the Japanese have their portable writing implements. Fig. 6 shows the kind of thing the milkman, the baker, or the tax collector carries in his sash when he goes on his rounds. It is made of bronze. The tube contains his pen, while the beehive-shaped box at the other end of the silken cord contains ink. The box consists of two compartments; the lower one contains the Indian ink in a sponge, and the upper compartment holds some red indorsing ink with which he charges his business seal with ink, and indorses his little bill or receipt.

Japanese Pen Tube and Ink Box (Ivory).—In Fig. 7 we see a more elaborate form of the same kind of implement, made of ivory. The stem is hollow, and holds the pen. The whole is richly carved, as is also the bowl containing the sponge saturated with ink. It will be noticed that the general outline of this is very similar to that of the reed tube and ink bulb already referred to.

From the stylus of the ancients to the goose quills of our fathers was a great step in advance, but the requirements of advanced civilization demanded still further strides. The softness of quill pens and the constant trouble required to mend them and keep them in working order naturally led to the search for some more enduring substitute.

Quill Nibs.—In September, 1809, appeared an application from Joseph Bramah (3260) for "a new method of making pens, penmaking machines, etc." This is interesting, as it marks the date when quills were first cut up into several pieces, and as many nibs were formed therefrom. He describes how the quill may be cut longitudinally into three or even four parts, and each

FIG. 10.

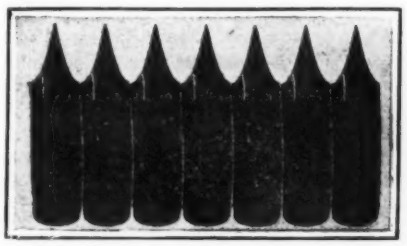


of these cut transversely into two, three, four, or even five parts, and a writing point formed at each extremity of these subdivided lengths. He then goes on to describe a machine whereby the quills may thus be treated. I shall have occasion to refer to this specification later.

In October, 1818, Charles Watt (4299) describes a process for gilding and preparing quills and pens by manual labor and chemical operations, so as to render them more durable and useful. He describes the process of cleaning and dipping in a dilute aqueous solution of the nitro-muriate of gold, treated with phosphureted hydrogen gas; then sulphurous acid gas, until finally, after repeated treatment, a thick coating of gold is deposited.

Quills with Steel Nibs.—In 1852, Myers and others obtained a patent (525) for the making of pens or nibs to be applied to quill holders. The specification also describes the shaping of quills at the end, so that they

FIG. 10A.



might be used as ordinary penholders to hold the nibs in general use.

Three years later a somewhat similar arrangement was patented (591) by William Hill.

The specification (7333) of Henry Stephens, of March, 1837, refers to certain improvements in pens for writing. He employs quill, horn, or other animal substance of the requisite thickness, which he cuts into proper forms by means of a cutting punch or other instrument. A pair of dies shaped according to the model or required curved or bent form of the pens intended to be made are heated to a degree sufficient to harden the materials without destroying their texture; the cut pieces or blanks are placed between them, subjected to pressure, and not removed till the dies are quite cold, when the nibs will have become set or fixed in the required form. In order that the slit may not be allowed to pass too high up, the pen is placed under a cutting punch and die, and a small hole is perforated at the place to which the slit is to extend. It is also stated that the curving process may be performed first, and the cutting and shaping afterward. A penknife may be used to remove any roughness, and also to adjust the points.

Charles Goodyear in 1853 describes a process (1693) for making pens of vulcanized India rubber, composed of two parts by weight of India rubber, and one part by weight of sulphur. This is rolled out into a thin sheet of the thickness of a strong quill, and then cut up into suitably narrow strips, which are placed between molds made of glass, one being concave and the other convex, and subjected to heat gradually increased to about 295 deg. to 350 deg. Fahr., and afterward allowed to cool gradually, when the curved strips are taken from the molds, cut into lengths, and made into pens.

In the specification (1856) of Henry Peters in 1853 the inventor states: "My improvement in pens consists in making them of tortoiseshell, and the other shells called tortoiseshell in commerce."

He presses thin sheets of such shell into a semi-cylindrical form, and from these he cuts the pens and fashions them by any suitable means. He states that pens made of tortoiseshell have all the desirable properties of quill pens and last much longer, and, like the quill, when worn can be mended in the same manner.

In 1859 (68) Edward Cobbold proposed making his pens principally from strips of reed or cane. These he divests, at intervals, of the soft spongy material which lines the interior. The pens are made from the hard outer shell, while the soft part forms a stop to the slit. This would appear to be a retrograde suggestion rather than an improvement.

In 1861 (2112) Evans and Concanen describe how pens may be made from horn in its natural structure, or dissolved and formed into horn sheets by ordinary process. Blanks are stamped or cut out from the sheets, softened by the heat of steam or other means, molded into pen form, provided with slits, and allowed to resume the natural state of the horn from which they were manufactured.

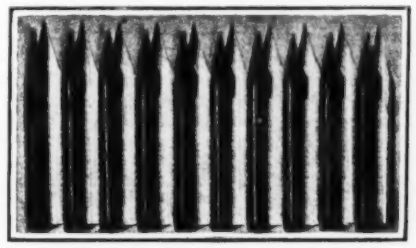
In the invention of George Leslie in 1861 (2828), the pens are made of hardened caoutchouc, gutta percha, or gum, known as vulcanite or ebonite. The inventor molds them into the proper shape while the gum is in a plastic state, and hardens them by the ordinary process, or shapes them with files or other tools, after the material has been hardened and become vulcanite or ebonite.

These examples will tend to show that quill pens were not considered perfect as writing implements. They were too troublesome to keep in order, and there was an evident desire to produce something more enduring.

It must not be supposed that I have cited anything like all the attempts that have been made to improve the quill, but I have selected these typical examples as illustrative of my suggestion that something better was required.

It is recorded that metal pens were used in the fifteenth and sixteenth centuries, and a writer (in 1733)

FIG. 11.



refers to steel pens. The following interesting note appears in a manuscript document in the library of Aix-la-Chapelle, entitled, "Historical Chronicle of Aix-la-Chapelle," second book, year 1748, edited by the writer to the mayoralty, Johann Janssen. He says:

"Just at the meeting of the Congress I may, without boasting, claim the honor of having invented new pens. It is, perhaps, not an accident that God should have inspired me at the present time with the idea of making steel pens, for all the envoys here assembled have bought the first that have been made, therewith, as may be hoped, to sign a treaty of peace which, with God's blessing, shall be as permanent as the hard steel with which it is written. Of these pens, as I have invented them, no man hath before seen or heard. If kept clean, and free from rust and ink, they will continue fit for use for many years. Indeed, a man may write twenty sheets of paper with one, and the last line would be written as well as the first.

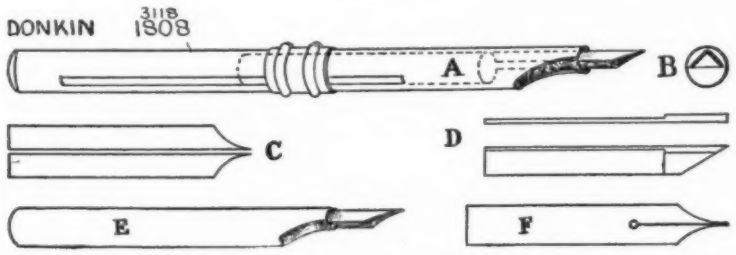
"They are now sent into every country of the world as a rare thing, to Spain, France, and England. Others will no doubt make imitations of my pens, but I am the man who first invented and made them. I have sold a great number of them at home and abroad at 1s. each, and I dispose of them as quickly as I can make them."

Barrel Pens as First Made.—There are many others who lay claim to having made the first steel pens, but the late Sir Josiah Mason has stated that his friend and patron, Mr. Samuel Harrison, a maker of split-rings, such as are used for keys, made a steel pen for Dr. Priestley about the year 1780. He, Harrison, took a sheet of steel, made a tube or barrel of it, the edges meeting to form a slit. He then filed away the edges of the tube in such a manner as to form a rough barrel pen. The illustration (Fig. 8) shows how the pen was fashioned, the slit extending right along the back of the barrel, not merely at the point as in the modern method shown below. The upper drawing in each instance illustrates the form each pen would assume if flattened out.

Harrison's method was improved upon by a blacksmith named Fellows, of Sedgeley, Worcestershire, who punched a rough "blank" out of thin sheet steel. He then formed this blank into the barrel shape, and while the metal was soft marked the place where the slit was to be, with a sharp chisel. Before tempering, this mark was "tabbered" or gently beaten with a small hammer until it cracked right through, thus forming the slit. Fellows began making pens in 1795, and was able to produce them at from 18s. to 30s. a dozen, whereas Harrison's were 5s. each.

***Donkin's Pens.*—In 1808 Bryan Donkin applied for**

FIG. 9.



and obtained the first patent (3118) for metal pens. He claims a pen upon a new construction, and states that the pen may be of any "metal or material fit and proper" for the purpose. It is made of two parts as shown at *C* "flat or nearly so," having those parts of the flat sides opposed to each other, and forming the slit of the pen, rather thicker toward the point as shown at *D*, in order, as he says, to prevent the pen from spluttering. They are then put into "a tube or other fit receptacle," "applied to each other in an angular position," as shown at *B*, and thus constitute a pen.

Another method is to form the pen of one single flat piece, as shown at *F*, afterward bent to the proper angle, before inserting it into the tube *E*. To increase or diminish the elasticity of the pen, the inventor suggests its being placed further out, or within the tube holder *A*, a slide being provided for this purpose. The patentee states that these nibs may be made of steel, brass, silver, gold, platinum, or any other suitable metal or material. Mr. Donkin's illustrations are reproduced in Fig. 9 redrawn from his specification.

Specimens of these pens are to be seen in the Educational Department of the South Kensington Museum.

Perry's Pens.—In the patent (5933) of James Perry, of April, 1830, we have an improvement in pens, consisting in producing them from hard, thin, and elastic metal, with the necessary flexibility, and a length of slitted or cleft space scarcely exceeding that of quill pens. The result is effected, first, by a central aperture space or hole of circular, oval, square, or other shape, formed in the pen between the nib and the shoulders or, secondly, by making between the nib and the shoulders one or more lateral slits on each side of the central slit, and rising out of or branching from it. The pens, the patentee states, should be made of the very best spring steel, and they should be of about the same diameter as those made from quills. It has been suggested that Perry got his idea of making steel nibs from having seen the quill nibs of Bramah, and there is probably some foundation for the suggestion. Hitherto, pens had only been made in barrel form in imitation of the reed and the quill, except in the case of Donkin's invention, which does not appear to have found much favor.

With such a variety of nibs as are to-day everywhere obtainable there ought to be no difficulty in finding one to suit every style of writing, from the hair lines of the lithographer to the broad, bold lines of the German text employed in engrossing legal and other documents. There certainly is no valid excuse for him who can never find a decent pen. And considering the many processes through which the pen of to-day passes before it is considered fit to place before a critical public, it is marvelous that pens can be bought at prices so low as fourpence a gross, which formerly cost as much as eight shillings a gross.

Perhaps I may now be permitted to give some general idea of the interesting growth of the steel pen of to-day, from the time of the punching out of the "blank" from the strip of very high quality steel from which it is taken.

Cutting Out.—The steel of course is in an annealed state, easily manipulated without fracture, and here is a photograph of a group of "blanks" (Fig. 10) as they fall from the die of the fly press, operated by girls, who become very deft and skillful at their work. The punching of the steel is so rapidly and neatly executed as to be done with mathematical precision. It will be found on examination that the intervals between the perforations are perfectly uniform. Having perforated the entire length of the ribbon of steel along one edge, it is quickly reversed, and the other edge is treated in a similar manner.

Side Slitting.—The next operation is that of forming the two side slits (Fig. 10A) which give elasticity to the nib. I need not now go into details as to how the various processes and operations are carried out, but will pass along from one to the other.

Piercing.—This operation has already been referred to, and the object of the existence of the "pierce" explained. Of course there are many nibs made without a pierce, notably gold ones, but most steel nibs are pierced to give them elasticity, and to increase their ink-holding capacity.

Marking.—Manufacturers who are proud of their productions take a pleasure in stamping their name on the nibs they make, and in order to identify one kind of nib from another, a mark, or a letter, or a name is stamped on the nib to be seen of all men. On the other hand, there are manufacturers so modest that for a mere consideration, they will stamp someone else's name on the nibs they make. In the illustration, we have the name of Joseph Gillott, whose name is known throughout the civilized world.

Annealing.—The various manipulations having somewhat hardened the steel, it becomes necessary to soften or anneal the blanks previous to further development of the nibs. They are moderately hard, but before they can be made to assume the familiar curved form, it is necessary that they should be considerably softened, so as to be of a more yielding disposition, and to effect this quantities of the immature nibs are placed in iron pots, afterward carefully covered with charcoal dust, and sealed to prevent the entrance of furnace gases. Thus prepared, the pots are placed in larger pots of the same kind and again covered and sealed, and then placed in a muffle furnace till they become of a dull red heat, when they are taken out and allowed to cool. The blanks have now become soft and pliable, readily taking the various shapes into which pens are formed by stamping and embossing presses.

Raising.—There is now no difficulty in making the blanks assume the appearance here shown in Fig. 11 by a process technically known as "raising," but, as the nibs are soft, their constitution having become limp and enfeebled from the recent annealing process, they must be braced up anew in the hardening tub, for now they have no more elasticity than so many pieces of lead. They look like nibs, and that is all.

Hardening.—Hardening is accomplished by heating the nibs to a dull red, having placed them first in shallow pans, and then, when at the right heat, which is estimated by their color, they are overturned into a bath of oil, from which they are afterward removed, having a greasy, black, disreputable appearance, and a temper as brittle as glass. Boiling in a strong solution of soda and water removes the grease and impurities, and the nibs emerge with a white and clear complexion, but they are much too brittle.

Tempering.—They have next to submit to the process of tempering, which is effected by placing a quantity of them in an iron cylinder, capable of being slowly revolved over a fire, or gas jet. Under this treatment, as everyone knows, they change color with perfect regularity, and as soon as they are seen to assume a dark blue color they are taken from the fire and allowed to cool.

Cleaning.—The nibs, however, again require to be cleaned to remove the impurities caused by heating and handling. They are therefore put into tumbling barrels, containing water and powdered fireclay, the fragments of crucibles and foundry melting pots, mixed with emery. These barrels are kept revolving for some time, till by abrasion the nibs are at length polished with a surface like silver.

Straight Grinding.—To improve the flexibility of the nibs, they are now ground near the points in a longitudinal direction, equivalent to the scraping of a quill pen with a penknife.

Cross Grinding.—And then they are ground in a transverse direction, a process which gives them a smart appearance.

Messrs. Gillott had an ingenious little machine in their works in Birmingham, which automatically ground the nibs, first in one direction and afterward in the other direction as described, at the rate of about twenty-four in a minute, the pens being fed into the machine at this rate by hand. After grinding, the nib was released and projected with considerable force along a tube, and into a basket placed below. On the occasion of a royal visit to Messrs. Gillott's works, His Majesty King Edward the Seventh, then Prince of Wales, was much interested in the little machine, and having watched its lifelike movements for some time, caught one of the flying nibs as it emerged from the tube, the result of which was a small puncture of the palm of the royal hand. This incident gave rise to the naming of the machine, which my guide (who narrated the incident to me when I visited the works) introduced to me as the "Royal Blood Machine."

Slitting.—Perhaps the most important process in the making of a nib, remains to be carried out. It is that of slitting, but time will not permit me to go into the method in detail. Suffice it to say that the slitting is now accomplished, and if properly done, a perfect nib is the result.

Coloring.—In order to improve the appearance of the nib, or as a distinguishing feature, it is now colored by a gentle heating, which gives it the familiar bronze color. Or, sometimes the nibs are plated with copper, or gilt, or nickel-plated.

Varnishing.—Finally they are varnished by immersion in a solution of shellac dissolved in spirit, made to adhere to the nibs by gentle warmth. When dry, they are examined carefully, all defective nibs being rejected, weighed into grosses, and carefully packed in neat cardboard boxes, ready to be introduced to the world as an instrument "mightier than the sword." At the present time, there are about thirteen or more firms engaged in the pen-making trade in Birmingham alone, consuming about 28 tons of steel per week in the production of pens and penholder tips. Besides the British factories, there are some four or five on the Continent, and perhaps only two or three in the United States. In Birmingham alone, the average weekly production equals about 250,000 gross, or 36,000,000 pens, finding employment for some 4,000 women and girls, and about 650 men and boys. In addition to these, about 300 more women and girls are employed in making the neat paper boxes in which the pens are packed. That the industry is an important one there can be no doubt. Messrs. Gillott's works in Birmingham are very extensive, and those of Messrs. Perry & Co. are no less important. Messrs. Brandauer also have a huge factory. Besides these there are other works in Birmingham of equal importance, such as John Mitchell's, Myers & Sons, William Mitchell's, and others whose names are familiar to all.

Many attempts have been made to find a substitute for steel in the manufacture of pens. It is not a great many years since it was almost an impossibility to find an ink that did not rapidly corrode metallic pens, by reason of the ingredients used in its manufacture. Even to-day we are warned that certain inks are highly corrosive. Several patents were granted to inventors for the application of certain metals, other than steel, to the making of pens, and the following are a few of them, by way of example.

In 1822, Hawkins and Mordan describe certain improvements in pens (4742), consisting in making them of tortoiseshell or horn, and impressing into the wearing parts, when they are softened with hot water, small particles of diamond, ruby, or other very hard substance. And again: In lapping a small piece of thin sheet gold over the end of a piece of tortoiseshell, and pressing the gold into it while in a soft condition. The pen is afterward formed by cutting away the superfluous gold and tortoiseshell together. And again: By applying to the nibs of pens of tortoiseshell, horn, or quill, small particles of diamond, ruby, or other gem, causing them to adhere by a suitable varnish or cement unaffected by ink.

Scully and Heywood, in 1855 (2084), suggest that, by reason of its non-oxidizable qualities, aluminium may be used in place of brass, copper, and silver, for wind and stringed instruments, and also as a material for pens, penholders, and inkstands. The metal for pens they propose to roll or beat into thin sheets, in order to give rigidity and toughness to it, and then, by ordinary means, the pens may be made from these sheets.

In the invention of Bewicke Blackburn (804) in 1857, each pen is formed of two pieces of glass or porcelain (set in a frame of metal or some other flexible material) composed of two parts, separated from each other in such a manner that the flexibility of the frame will admit of the points of the pen separating or expanding, and contracting when writing.

In the months of February, March, and May, 1863, three distinct groups of inventors (Robert Pinkney 455, Lutwyche and Lutwyche 682, and Page and Wayne 1165) applied for patents for making pens of aluminium bronze, composed of aluminium and copper in varied proportions. This appears to be a peculiar coincidence.

In the invention of Louis (1711), in 1876, the pen is to be of gold, of not less fineness than 16 carats, covered with vulcanized India rubber, and provided with an iridium tip or point.

These are specimens of the many efforts on record of inventors striving to improve the pen, and one cannot help but admire the ingenuity and skill, as well as the perseverance which such records represent. On the other hand, it was no doubt assumed that considerable fortunes were to be realized in case of success. Experience has shown that a greater harvest of wealth has over and over again been reaped by the inventors of small articles of general utility, than has fallen to the lot of originators of more pretentious inventions.

(To be continued.)

A RATIONAL PROCESS FOR OBTAINING AMMONIA AND SAL-AMMONIAC BY THE UTILIZATION OF RESIDUARY AND WASTE PRODUCTS.

In a patent covering a process for procuring ammonia from guano granted to Young, vertical cylindrical retorts are filled with two parts of guano to one part of calcic hydrate or some other caustic alkali, and the two substances mixed by means of a stirrer. The mixture is then gently warmed and the temperature gradually raised to a red heat. All the nitrogen of the guano is converted into ammonia under the combined action of the heat and the alkali. As a result we obtain not only the ammoniacal salts already present, but also the nitrogen of the organic compounds always existing in guano, in the form of ammonia.

To obtain aqueous ammonia from the gas liquor from gas works by Watson's process, the *modus operandi* is as follows: The crude gas liquor is mixed with lime, the quantity of the latter depending upon the quality of the water, in a large retort or boiler connected with a condenser, and heated. The gas is soon driven out and absorbed by the water in the receiver, and after considerable heating a large quantity of water is distilled over. As soon as this is noticed, the receiver is changed and the following distillate collected separately till the last portion of the liquid shows no, or only a slight alkaline reaction. This portion is again placed in the still to be concentrated by a second distilling process. Even the portion first distilled, however, is not sufficiently pure. It usually contains oily substances, which can be separated mechanically, and in addition a considerable excess of water. It is accordingly subjected to a further distillation. The ammonia gas is received as before in a vessel containing water and the latter changed as soon as too much water is distilled over. An aqueous ammonia is thereby obtained, good enough for nearly all technical purposes. The second portion of the distillate is preserved for the next treatment, and then again put into the still.

Referring to this process, Stohman rightly observes that it is unpractical, for the reason that several distillations are necessary to obtain a marketable product. This drawback can be avoided, he adds, by a methodical process of distilling, in which the concentration of the ammonia in the vapor and the elimination of foreign substances can be effected during the operation. The apparatus necessary for this process is constructed on the model of the improved spirit stills by means of which high proof alcohol, free from fusel oil, can be obtained directly from mash.

A liquid containing carbonate of ammonia as its principal ingredient can be prepared by dry distillation of bones. Laming prepares this liquid from aqueous ammonia by first adding calcium chloride. In this way insoluble carbonate of lime and ammonium chloride (sal-ammoniac) are formed. He separates the liquid from the precipitate and boils it for an hour, thus removing all volatile and gaseous impurities. As soon as the liquid cools, he adds to it a sufficient quantity of ferric hydrate, whereby all sulphides are converted into insoluble sulphides of iron, then slaked lime to set free the ammonia, and finally distills it.

L'Hote makes use of the waste material or scrap

from wool, hides, leather, horn, feathers, and sponges, which contain from 6 to 15 per cent of nitrogen, for obtaining sulphate of ammonia. If this refuse is treated with a solution of caustic soda in 9 or 10 parts by weight of water, and in the cold or with a gentle heat to prevent the evolution of ammonia, a part will be entirely dissolved and a portion at any rate decomposed. The gluey liquid thus obtained is mixed with slaked lime to form a pasty mass, which is put into an iron retort communicating with receivers containing chamber (sulphuric) acid. The distillation of the mass is then effected with a temperature as low as possible to prevent the dissociation of the ammonia. When the evolution of gas has ceased, the retort is heated to a red heat, and when the operation is completed, a white, powdery residue, consisting entirely of carbonate of soda and quicklime, will be found in the retort. If this residue is treated with water, caustic soda is again formed, which can be used in a subsequent operation. The sulphate of ammonia thus procured is colored and may be purified by crystallization.

For obtaining pure ammonia from gas liquor, W. M. Brown took out a patent in England for the following process for J. H. Elvert of Geneva and J. J. M. Pack, of Basle:

The gas liquor is mixed with a suitable quantity of lime in a closed cylinder or boiler, and then drawn off into a second vessel and heated. The escaping vapors and gases are conducted to the bottom of the first vessel, which has meanwhile again been filled with gas liquor and lime, and from here, enriched with ammonia, into a condensing chamber. From the latter the more easily condensable constituents flow through a connecting tube back to the last-mentioned vessel (No. 1) while the more volatile portions pass through the worm into a second condensing chamber, where hydrocarbons, sal-ammoniac, and a small quantity of free ammonia are retained. The purer uncondensed vapors are passed through several vertical pipes charged with charcoal into receivers filled with distilled water, and which are changed after saturation. As soon as all the ammonia has been driven out of vessel No. 2, the latter is emptied and charged with the contents of No. 1. No. 1 is filled as before, and the operation repeated. In the course of four or five hours, 265 gallons of crude water of 3 deg. B. treated in this manner will yield from 220 to 240 pounds of commercially pure liquid ammonia of 22 deg. B.

The apparatus hitherto used for distilling the gas liquor from the gas works either consisted of one boiler, in which the liquid, with or without the addition of lime, was distilled, or two vessels were employed, one of which served as a preheater, and the other as the still. If no lime were added, only ammonia in combination with volatile acids was obtained; in the other case, the added lime made the vessel extremely liable to burn away speedily. This drawback was by no means satisfactorily obviated by the introduction into the apparatus of a stirring contrivance.

These defects are avoided by a contrivance designed by H. Gruneberg, of Kalk, near Deutz, which permits of the employment of lime without a mechanical stirring apparatus, and consequently of the extraction of all the ammonia, including the ammonia in combination with chloric and sulphuric acids, without danger of damage to the apparatus.

The fresh gas liquor passes from a store tank into a boiler from 7 to 8 yards long. It is here subjected to a preliminary heating, then it is run into a second boiler provided with a furnace, and afterward into a third boiler not in contact with the gases of combustion. It is here treated with lime, to decompose the non-volatile ammoniacal compounds, and is drawn off after exhaustion. When the apparatus is in regular work, the second boiler is heated; the gases proceeding from it surround the first boiler and heat its contents to the boiling point. The vapors evolved in the second boiler pass through a tube with a rack-shaped end into the third boiler and drive out from the latter the ammonia set free by means of lime-milk poured into it through a funnel. This free ammonia with the steam escapes through a tube into the preheater, disengages in the latter the volatile ammoniacal compounds and is conducted along with these through a pipe into covered lead boxes filled with a 50 per cent sulphuric acid solution. The gases here evolved, viz., sulphureted hydrogen and carbonic acid, are passed through a conduit into the furnace of the second boiler and thus rendered harmless.

When the acid in the saturation box is neutralized, the lye thus obtained is left to cool and the crystallized salt dipped out upon the dripping device while the mother lye is again mixed with a suitable quantity of sulphuric acid and treated with ammonia vapors, so that a special evaporation is not necessary. If sal-ammoniac is to be prepared, the lead boxes are replaced by stone boxes filled with hydrochloric acid; in this case the evaporation of the lye cannot be dispensed with. This apparatus has been introduced into ammonia factories of Cologne, Hamburg, Stettin, and Leipsic. Experience has shown that it is easy to operate, and requires but little repairing, and that the treatment of the gas-liquor is satisfactory in every way.

To recover sal-ammoniac from gas-liquor, the latter is treated, either by first adding lime in quantities depending on the amount of ammonium chloride or sulphate of ammonia, distilling it, and passing the ammonia thus obtained into hydrochloric acid, or by immediately neutralizing the gas liquor with hydrochloric acid. The best and chemically purest product is obtained by the first method.

The liquor, with the addition of some quicklime, is heated in a large vessel till it boils; the vapor is then passed through a worm surrounded by cold water in order to condense the greater part of the water, and the distillate allowed to flow into a receiver filled with hydrochloric acid. This receiver is a wooden box thickly lined with lead, and closed by a lid. From this box the non-condensed gases, sulphureted hydrogen, etc., are conveyed by an exit-tube under the furnace of the boiler, where they are burned, and thence into the chimney. The end of the worm dips into the acid, so that all the ammonia, which is only partially condensed in the condenser, is compelled to combine with the acid.

When about the tenth part of the liquid in the boiler has been evaporated, all the ammonia of the liquid is apparently expelled, and this will be shown by exposing a piece of litmus paper to the vapor issuing from a vent-faucet. This faucet is then left open and the boiler emptied; thus allowing the air to penetrate into the faucet and prevent the sal-ammoniac solution from rising again.

The ammonia gas is allowed to enter the acid till the latter is just neutralized; the salt solution is then drawn off and the receiver charged with fresh acid. The sal-ammoniac solution is generally so highly concentrated that it requires only a slight evaporation to acquire the degree of strength requisite for crystallization. If it is then allowed to cool, a beautiful crystallization, of pure white color, and entirely free from tarry substances, will at once be obtained.

The distilling process may be performed in a still more practical manner by connecting two boilers by pipes and change-cocks in such a way that the vapors may be made to pass from one boiler to the other. The first boiler is then heated directly by a furnace; the latent heat of the vapor causes the liquid in the second boiler to boil, and volatilizes the greater part of the ammonia, so that the ammonia from both liquids, together with the vapor issuing from the second boiler, is driven into the acid. As soon as the first boiler is exhausted, it is emptied and refilled; a fire is then lighted under the second boiler, in order to make the vapor from the latter pass into the first boiler, and the ammonia from this first boiler passes into the acid, and so on, till the second boiler also is exhausted, when it is again filled. A great saving of fuel is secured in this way, as a double quantity of ammonia can be prepared with almost the same quantity of fuel necessary for the distilling of the liquid in one boiler. Another advantage is that a much smaller quantity of steam passes over with the ammonia gas, so that a far more highly concentrated sal-ammoniac solution is obtained.

Utilization of waste material in the preparation of lye.—Caustic lyes, such as the lyes of soda and potash, are, it is known, composed of 10 parts of calcined soda, 100 parts of water and 20 parts of fresh slaked lime, the soda being first dissolved by boiling and the powdered and sifted slaked lime gradually added. The boiling process must be continued till no more carbonate of soda remains in the liquid, and the carbonic acid has combined with the lime to form carbonate of lime. Caustic soda will now be present in the liquid. After cooling, the clear caustic-soda lye is carefully drained off and put into closed bottles or carboys in order that it may not attract the carbonic acid of the atmosphere. The pulpy residue in the boiler is put into linen percolators previously moistened with water so that all the caustic lye may drain off, the carbonate of lime remaining in the percolator. The lime in the percolators is generally washed with warm water in the factories; in this way a somewhat weaker lye is obtained, which can be used in further operations, i. e., in the boiling of fresh lye. The lixiviated pulpy residue is then put into wooden boxes with very small holes at the bottom and covered with coarse filtering linen. Some lye will continue to drain away; the mass acquires greater consistency and is placed in molds, like those used in making briquettes. The resulting bricks are laid on boards, dried in the air and ground and sifted very fine to remove any impurities. The finely sifted powder is then used in various manufactures.

To make artificial chalk, the mass is molded, pressed, and slowly dried. It will then be as hard and firm as natural chalk, and can be easily cut so as to be used for writing purposes. Water-glass is added for a binder.

To Make Artificial Manure.—The dried lye-residue always contains a certain percentage of alkali, which cannot easily be removed by washing. Combined with other fertilizing material, it makes a good manure, especially when mixed with sifted wood ashes, bone powder, ground poudrette, or dry blood in definite proportions. The following combinations may be recommended:

Fifty parts ground lye-residue, 25 parts sifted wood ashes, 20 parts bone powder, 20 parts poudrette, dried and powdered excrements, 10 parts blood powder.

Fifty parts ground lye-residue, 50 parts disintegrated bone powder, 30 parts ground poudrette, 30 parts sifted wood ashes.

Sixty parts ground lye-residue, 60 parts sifted wood ashes, 30 parts ground kainite, 40 parts ground poudrette.

All these ingredients should be well mixed, sifted, and immediately packed in cases, which must be well closed.

For the use of lye-residue in the preparation of polishing powder and paste, the following will be found a good recipe:

Polishing Powder.—Finely powdered residue containing soda, 50 parts; finely powdered English red, 20 parts; finely powdered magnesia, 10 parts; finely powdered glass, 20 parts. These ingredients to be ground together very fine and sifted.

Polishing Paste.—Finely powdered residue containing soda, 60 parts; kieselguhr, finely sifted, 40 parts; English red, 20 parts; finely powdered glass, 20 parts; magnesia, 10 parts. The above substances must be well mixed and then thoroughly ground to a paste in a color-grinding apparatus with stearine oil.—Translated from Handbuch der rationellen Verwerthung, Wiedergewinnung und Verarbeitung von Abfallstoffen jeder Art von Dr. Theodor Koller.

LIGHTNING CONDUCTORS ON THE WASHINGTON MONUMENT.*

THE lightning conductors, as established for the monument, were commenced in January, 1880, and were finished in January, 1885. These conductors consist of four hollow wrought-iron Phœnix columns standing in the well of the shaft, and which support the elevator machinery and guide the car. These columns are 6 inches in exterior diameter, five-eighths of an inch in thickness, and are made up of sections 20 feet in length fastened together with long inside couplings, which fit tightly into the columns, and are fastened to them by sixteen screw bolts. The bottoms of these four columns rest upon and are bolted to cast-iron shoes, which in turn stand upon the floor of the large drum pit beneath the floor of the monument. The shoes are connected to ¾-inch soft copper rods led to the bottom of a well in the center of the foundation. This well is 32 feet 10 inches in depth below the bottom of the drum pit, and 15 feet 8 inches below the bottom of the masonry foundation, and the water stands in it permanently 2 feet 8 inches above its bottom. After the copper rods were inserted the well was filled with clean, sharp sand for a depth of 15 feet 8 inches, or up to the level of the bottom of the old rubble-stone foundation of the monument. These four columns so arranged at their bases, and always projecting above the top of the shaft, were continually lengthened as the building of the shaft progressed, and for the five summers during which the masonry was in progress acted as the lightning conductors of the edifice. No disruptive discharge of electricity was experienced during those five years.

When the walls were completed, in December of 1884, and the upper extremities of the columns were covered in by the marble pyramidion, four copper rods, three-quarters of an inch in diameter, were run, one from each column, to the top stone, and there united in a 1½-inch copper rod, which passing vertically through the stone, was screwed into a solid metal terminal of aluminium. This metal was selected for the terminal because of its whiteness, and the probability that its polished surfaces would not tarnish upon exposure to the air. It was a square pyramid in shape, similar to the pyramidion of the obelisk, and, fitting upon the top stone, completed the apex. This terminal weighed 100 ounces, and was 8.9+ inches in height, and 5.6+ inches in width at the base. The angle at the vertex between two opposite sides was about 34 deg. 48 min.

The conductors, as above described, when tested gave an electrical resistance of one-tenth of an ohm from the tip of the terminal to the copper rods at the base, and two and two-tenths ohms for the ground connections, making a total resistance of two and three-tenths ohms for the conductor. The system was entirely completed and connected on January 20, 1885.

On the 5th of April, 1885, during the passage of a heavy thunder cloud over the monument, at least five immense sparks or bolts of electrical light were seen within a period of twenty minutes to flash between the terminal and the cloud, without audible sound to the observers. A careful examination of the conductors and shaft after these phenomena failed to reveal any effects from these discharges.

On the 8th of June, however, during a thunderstorm, a disruptive discharge was seen to pass between the summit of the pyramidion and the cloud. Upon examining the structure a crack was discovered in the stone on the north face of the pyramidion just under the top stone, extending through the block in a line nearly parallel to the northeast corner, and about eight and one-half inches from it. The fragment was pressed outward about three-quarters of an inch at its bottom, chipping a small piece off the lower corner of the top stone into which it was locked, and was easily forced back to place and bolted to the solid stone from which it had been torn.

Under the circumstances of this damage, and to devise if possible some plan by which the obelisk could be more effectually protected from lightning, Profs. H. A. Rowland, of the Johns Hopkins University, Simon Newcomb, of the United States navy, and T. C. Mendenhall, of the United States signal service, were invited to inspect the conductors and recommend any modifications in them, which in their judgment would be proper for the end required. This they kindly consented to do, and after a careful examination recommended, in substance, that the interior conductors should be connected with a system of rods and a greater number of points to be located upon the exterior of the pyramidion. The additions, as devised by them, consist of four one-half inch copper rods, fastened by a band to the aluminium terminal and led down the corners to the base of the pyramidion; thence passing through the masonry they extend inward, and are joined to the iron columns above described. As these exterior rods are each over 60 feet long, they are also connected at two intermediate points of their lengths with the iron columns by means

* From Bulletin 37 of the United States Department of Agriculture.

of copper rods one-half and three-quarters of an inch, respectively, furnishing sixteen rods in all connecting the exterior system of conductors with the interior conducting columns. Where the exterior rods upon the corners cross the eleven highest horizontal joints of the masonry of the pyramidion, they are connected to each other all around by other copper rods sunk into those joints. All of these exterior rods, couplings, and fittings are gold plated, and are studded at every 5 feet of their lengths with copper points 3 inches in length, gold plated, and tipped with platinum. There are 200 of these points in all.

THE MODERN TELEPHONE SWITCHBOARD.*

By J. J. CARTY.

DURING the ten years just passed, a revolution has taken place in the design and construction of telephone switchboards, the magneto-switchboard, so called, having given way to the common battery switchboard. This radical change in telephone practice made new demands upon the telephone engineer, for it became necessary for him to introduce into central office construction certain elements which had theretofore been utilized principally in engineering work involving electric light and power installations.

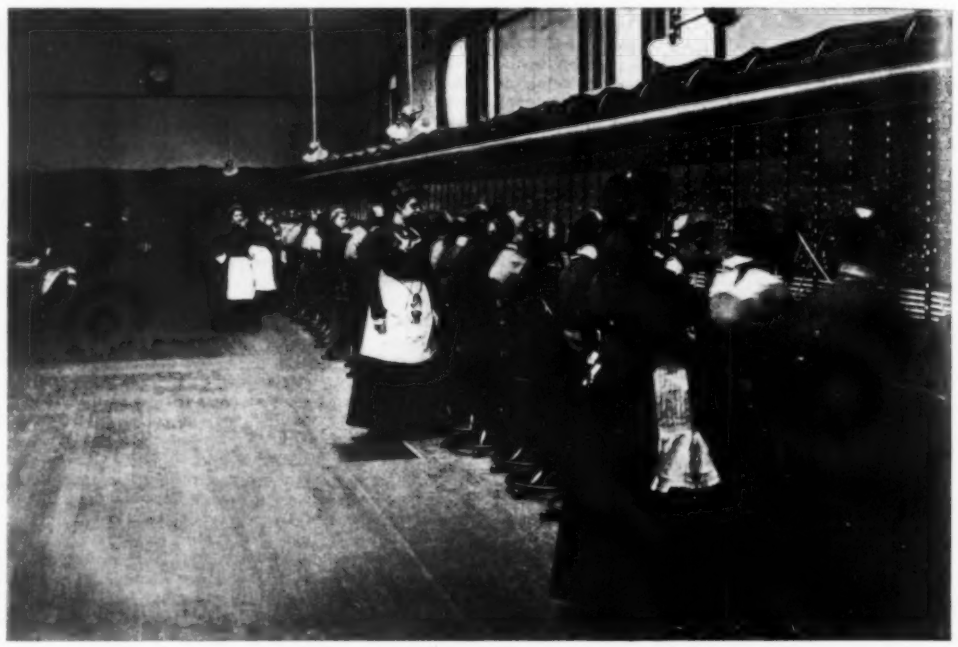
In the magneto system signaling from the subscriber's station to the central office was accomplished by means of a small alternating-current generator turned by hand, and the current supply needed in the working of the transmitter was obtained from a few cells of primary battery located at the subscriber's station. By the introduction of the common battery system all of this was changed. The magneto-generator was dispensed with as was the primary battery, the current supply for operating the transmitter, as well as that required to enable the subscriber to signal, being drawn from a large storage battery located at the central office.

In the case of a 10,000-line switchboard the storage battery must be capable of giving an average discharge of 500 amperes, and to insure proper working conditions it must be capable of giving a safe discharge as high as 2,000 amperes. For charging such a battery as this suitable machines must be employed, and these must be present in duplicate or triplicate. The standard machine used for charging a battery of this type delivers 1,000 amperes.

The introduction of currents such as these, and the introduction of these machines and of a large number of auxiliary machines generating currents for special purposes, has resulted in the creation of a power plant at each central office, upon which the operation of the telephone switchboard and apparatus is wholly dependent. The introduction of these larger currents has necessitated most careful and refined methods of fusing and protecting the delicate telephone apparatus. These protective methods, while following the general principles of such methods in electric light and power practice, are vastly more refined in their working and call for a hitherto unattained degree of precision in the manufacture of such apparatus.

Where a dynamo is to be constructed to operate incandescent lamps, let us say, certain minute fluctuations in the potential of the machine are permissible. Were such a machine, however, to be used in connection with telephone circuits, these fluctuations in potential would be sufficient to produce such constant humming in the telephone as to render it inoperative. Hence a greater refinement of the construction of these machines in this respect is imperative where they are employed in the telephone power plant.

So it is with the storage battery, where a number of telephones are supplied by current from one storage battery; even almost infinitesimal changes in the voltage of the battery might be propagated to the telephone lines connected therewith and produce disturbances. For this reason storage-battery practice from the telephone point of view presents problems which are different from those encountered elsewhere.



GENERAL VIEW OF THE MULTIPLE SWITCHBOARD OF A TELEPHONE EXCHANGE.

One of the interesting and important developments in the modern common battery switchboards is the extensive use which has been made of incandescent lamps in signaling. Hundreds of thousands of these lamps are now used for telephone signaling, and the requirements of the telephone art have called for special refinement in the design and manufacture of these lamps.

While the common battery switchboards as now used in all of the large central offices represent a revolution in methods, as compared with the magneto system, there are certain elements formerly used in the magneto system which have persisted. Among these is the multiple-board principle. This principle, as is well known, consists in extending a number of lines to different points in the switchboard so that it is possible to connect with them at any one of these points.

INDIVIDUAL SUBSCRIBER WIRES.

The multiple system is opposed to the transfer system, which is one wherein the lines are not so extended or multiplied to different points, but proceed directly to a special location from which trunk lines extend to other parts of the switchboard, so as to provide for making the necessary connections.

In a self-contained central office, with relatively few trunk lines extending to other offices, it is found most economical to multiple all of the subscribers' lines to each section of switchboard. In very large cities, where a number of central offices are required and where the amount of trunking between the different central offices is relatively large, the advantage of multiplying all of the subscribers' lines to each section is not so apparent as in the case of the self-contained office, and this fact has led many to the conclusion that for such situations multiple boards are not adapted. But this is going farther than the fact warrants, for while it is true that the advantage of multiplying the subscribers' lines to all of the sections of the switchboard becomes less and less as the percentage of trunking increases, it is still a fact that the point is never reached where the multiple principle should be abandoned entirely.

The truth of this proposition may be easily established by assuming that in a large city all of the calls must be trunked, and that none of them is local to the office in which they originate. In such a case as this it is obvious that nothing could be gained by extending all of the subscribers' lines before each of the operators. On the other hand, it is still essential that the outgoing trunk lines should be extended, or multipled, before all of the subscribers' operators, and all of the subscribers' lines should be multipled before the trunk operators. While the case of an office without any local calls is one which could not occur in practice, there are situations in which the amount of local calls is so small that it will not pay to multiple the subscribers' lines to all of the subscribers' operators. Just when this point is reached is a question to be determined in each case.

Thus far the instances where it has been found possible to omit this multiplying of the subscribers' lines are few, but as time goes on the number of these cases must increase; but at no time, so far as can now be seen, will the point be reached where the multiple principle itself will be abandoned. Even in the automatic switchboards, which constitute one of the most interesting of the recent developments, the multiple principle is found to be essential to the working of all types of automatic boards thus far proposed, wherever the switchboard is of any substantial magnitude.

* Abstract of a paper presented at the 230th meeting of the American Institute of Electrical Engineers.

THE MIXING OF CONCRETE.*

By ERNEST MCCULLOUGH, C.E.

IN the "Cambria Handbook" allowable pressures for masonry per square inch are as follows:

Ordinary stone	180 pounds
Good stone	300 pounds
Brick in lime mortar	150 pounds
Brick in cement mortar	200 pounds

Trautwine states that neither stone nor brickwork should be trusted with more than one-sixth to one-tenth the following loads, according to circumstances:

Limestones and marbles	3,470 to 13,880 lbs.
Granites and syenites	4,170 to 12,500 lbs.
Connecticut brownstone	5,555 to 13,472 lbs.
Ordinary brick masonry	278 to 417 lbs.
Brick in good cement	700 to 972 lbs.

According to Trautwine therefore some of the allowable Cambria loads for brickwork are excessive. It is likely the "Cambria Handbook" contemplates the best of brick while Trautwine takes ordinary house brick.

While Trautwine and others recommend a factor of safety of from six to ten in all structures made of stone masonry and mention the same factors for brick masonry, it is seldom so high factors are used for brick, owing to the perfect control that may be had over the manufacture of brick and good cement mortar.

Faults and well defined bedding planes and cleavage lines in natural stone make it impossible to rely upon

* Michigan Technic.

most natural stones with any certainty for strength. Aside from the consideration of mere crushing strength, must be also considered durability. Before any natural stone can be used in an exposed situation trial must be made of its durability. If no stone of the kind has been used in that neighborhood and there is no past experience to govern, then chances must be

A PORTION OF THE "A" BOARD, SHOWING MULTIPLE JACKS, OUTGOING TRUNK-JACKS, ANSWERING-JACKS, AND PLUGS.

taken. It requires years to test a stone for durability, and of the many accelerated tests in use none so far has proven perfect. The pitiful appearance of much expensive stone carving and the crumbling of many great edifices show lack of care, or perhaps lack of time, used in selecting the stone.

In properly constructed concrete we have a material that is better than the best natural stone. It is not an artificial stone, for it imitates nothing. It is a manufactured stone which is an improvement on the natural product. It can have no greater strength than the materials of which it is composed, but it can be made more uniform in texture and more dependable for strength and durability than the best of stone Nature produces accidentally.

The impossibility of making an accurate chemical analysis of all stone used prevents anything more than a good guess as to the probable ultimate life in a structure. With brick and cement the uncertainty can be reduced to a reasonable minimum. With concrete it is still better.

Natural cement is made from materials found in a natural state, and the manipulation of these materials necessary to convert them into cement for the market is simple. Yet natural cement will not weather well for it contains within itself the elements of destruction. Portland cement is made of different elements found in a natural state but they are combined in a laboratory and undergo processes that give them a maximum power of resistance so that Portland cement is durable.

Portland cement in the process of manufacture is tried by water and fire, the two great enemies of all structures. It is therefore manifestly fitted to be an ingredient of a manufactured stone. In nature many chemical and mineral substances are combined and cemented together to form a stone which, in the formation, takes to itself the elements that afterward combine with other elements in the atmosphere to accomplish its destruction. In well made concrete the natural stone is taken together with sand, or ground stone, and Portland cement is used as a cementing medium to bind them together. Proper cementation has two effects. One is to give the material great strength, the other is to protect the concrete from disintegration. These different results are obtained by the process of mixing, and good mixing therefore requires that every face of each piece of stone and every face of each grain of sand be thoroughly coated with cement mortar. In this way they are thoroughly cemented together and at the same time protected from the atmospheric influences that may endanger the stone. It is to be remembered that each piece of stone and each grain of sand carries in itself the seeds of dissolution the same as if they were large blocks of stone. They must be protected from the atmosphere if concrete is to be better than the stone it is supplanting.

This line of thought shows why the most important thing in the making of concrete is the mixing. It is often said that all the voids in the stone must be filled with sand, and all the voids in the sand filled with cement mortar. This simply insures strength. If we add that all faces of both stone and sand shall be thoroughly coated with the weather-resisting cement then we have the best mixture. Some may say it means the same thing; but it does not. In the first definition it merely means that a fairly dense material is obtained containing certain definite proportions of aggregates that may, or may not, be uniformly distributed throughout the mass. In the second it means absolute uniformity of mixing—nothing less.

Concrete may be mixed by hand or by machine. There are three methods of hand mixing. The first is to mix the sand and cement dry until the mass is uniform in color. Then add water and make a paste. Upon this paste throw the stone, which has been previously wet, and turn the stone and paste over until the mass looks right. It is then ready to go into place as concrete. This method of mixing is theoretically perfect, but is slow, and therefore seldom done with care.

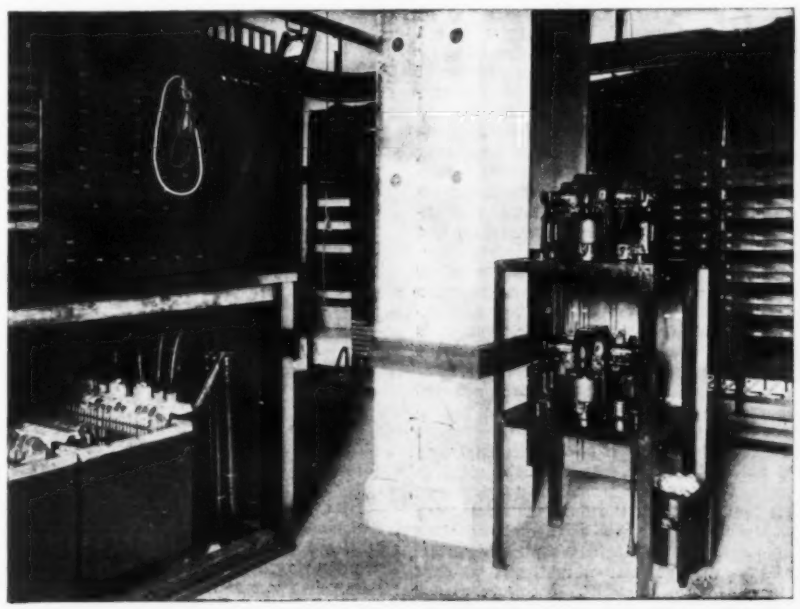
Another method of hand mixing is to spread the stone as many inches thick on a board as the concrete contains parts of stone. Over this spread the sand evenly and upon the sand spread the cement evenly. The mixing is done by putting shovels into the bottom of the pile so each shovelful contains approximately the right proportions. The mass is turned over twice dry, being shoveled forward and then back. Then it is turned twice while water is added through a hose nozzle. It gets a fifth turning in being put into the wheelbarrows. The writer prefers this method of mixing for two reasons: First, it is as thorough as the first method and, second, it can be done at much less expense—and expense is a great factor.

The third method consists in putting the materials on a platform as described above and shoveling them into the upper end of an inclined trough. This has spikes, shelves, or other forms of baffles so the material has to travel in a zig-zag manner, and during its progress water is added. This is often called machine mixing, and such a trough is called a gravity mixer. The mixing is done, however, on the board, and the zig-zag travel assists very little in the mixing process. The trough is only a conveyor that prevents, to some extent, the separation of the aggregates according to size and specific gravity. No one claims that each shovel contains, in exact proportions, the aggregates taken on it, yet each shovelful travels by itself down the incline. At the close of work it is safe to say the structure contains the proportions measured into it, but some places are rich and some are poor in cement.

Mixing by shovels and hoes depends for results upon recognition of the law of averages. This is proven by the table published in Engineering News of August 27, 1903, illustrating an article by Mr. Clarence Coleman, United States assistant engineer. He mixed many batches of cement mortar composed of 1 cement and 3 sand. Some batches were mixed one minute, some two, etc., until a maximum of ten minutes was reached. Tests were made in 7 days, 28 days, 3 months, 6 months, 1 year, and 2 years. In 7 days, mortar mixed ten minutes was 37 per cent stronger than mortar mixed one minute. In two years, mortar mixed ten minutes was 19 per cent stronger than mortar mixed one minute. Of course in the time between the seven-day test and the two-year test the concrete had increased in strength as it is known to increase. The increase in the ten-minute mortar was not so great, expressed in percentages, as the increase in the one-minute mortar, but it showed that the ten-minute mortar was the better and came nearer getting its maximum strength early than the mortar mixed a shorter time. The above shows very clearly that the law of averages must control in the hand mixing of concrete.

It is generally believed by men new in the concrete business that the sole benefit of a mixing machine is the lessened cost of mixing. Therefore to them any machine that puts concrete out quickly is good enough. This explains why the gravity mixer had a great many friends at first but now is used only where massive work is going in, and such a thing as fiber stress is not considered.

The gravity mixer is not always convenient to use because the concrete must be delivered at a point considerably lower than the point where the aggregates are piled. Therefore a class of mixers came in called continuous mixers. They are simply conveyors lying in a horizontal plane and actuated by an engine. The materials are fed in at one end and are delivered at the other. The materials are supposed to be fed in three continuous streams and the actual mixing space is very short and inadequate. The main function of the machine is to discharge at one end, in a combined form, the materials fed in separately at the other end. If such a machine is well arranged with an ample mixing space, and the three streams of material meet with no mishap, fairly good concrete can be produced. But the streams do not always flow evenly, and any lessening of weight in the piles behind the streams is effectual in disturbing the proportions. In most of these machines the stream of cement causes the greatest trouble. It is admitted that the poorest concrete is generally used in street foundations, and we seldom see to-day any continuous mixers used elsewhere under the charge of up-to-date engineers. The greatest blow to continuous mixers was given during the past year by the Underwriters' Association in requiring concrete in fireproofed buildings to be mixed in batch mixers, and refusing to allow hand mixing.



THE STORAGE BATTERIES AND A SECTION OF THE REPEATING-COIL RACK.

Batch mixers are mixers wherein each aggregate is placed in the mixing receptacle in certain definite proportions in batches, and each batch is mixed the same length of time. Absolute uniformity of product is thereby secured. The bag is generally taken as a unit, for one bag of cement is usually considered as one cubic foot. We therefore have one, two, three, etc., bag batch mixers. No preliminary mixing or arranging is done outside the mixing receptacle. Each aggregate is measured and thrown in, no attention being paid to the order of feeding, although some attention to it might help in certain makes of machines.

But batch mixers depending upon inside mechanism, while superior to continuous mixers, are still open to the objection that the law of averages applies to all mixers imitating the shovel action. The materials as they go into the mixing receptacle are immediately caught up by the deflecting mechanism and thrown around as with shovels. The process is first separation and then combination. They are better than hand mixing simply because a greater number of turns may be given the material, thus allowing the machine to mix in one minute as good concrete as a shovel will mix in seven or eight minutes. Thus the machine at a lower cost produces better concrete than shovels in the hands of men can produce.

The cost of mixing alone is very low. The principal item of cost in concrete manufacture is in the handling of the aggregates from the stock piles to the mixer and from the mixer to the structure. The machine has the further advantage that as the output is regular and practically continuous it permits the use of various forms of conveying apparatus better than wheelbarrows and carts operated by men or animals. Every opportunity for the introduction of labor-saving processes and machines is a step toward increase of output with a consequent lowering of cost.

The writer has been asked the question: "How much superior is machine-mixed concrete to hand-mixed concrete?" The best reply is to refer to government publications.

On pages 349-385, report of the Watertown Arsenal, 1897, will be found reports of tests of piers made with hand-mixed concrete, and of piers made with machine-mixed concrete. The average compressive strength of the hand-mixed concrete was 989 pounds per square inch, and the average compressive strength of machine-mixed concrete was 1,098 pounds, showing an advantage of eleven per cent in favor of machine mixing. Other tests made at the same place showed an advantage of twenty-five per cent.

On page 3784, Report of the Chief of Engineers, U. S. A., 1904, is an interesting table showing the results of comparing hand-mixed with cube-mixed concrete used in a pier in Duluth harbor. The hand-mixed concrete was "first-class concrete" according to government requirements. Forty-five briquettes of concrete (not mortar) were made and tested. On a 7-day test the cube mixed concrete was 47 per cent the stronger. On a 28-day test it was 23 per cent stronger. On a 6-months test it was 16 per cent stronger. On a 12-months test it was 13 per cent stronger.

Experienced contractors who have mixed concrete by hand and mixed it with a machine generally figure that two yards per day of fair concrete is close to the limit per man in a hand-mixing gang. With a proper machine at least seven yards per day per man can be counted on, and the concrete is better. The writer, from an extended experience in concrete work, and an intimate acquaintance, from actual use, with the leading machines in the market, feels the above to be a fair comparison.

The cube mixer, in its most improved form, is fed on one side and is discharged from the other side by tilting, not ceasing to revolve during the process of loading, mixing, and discharging. The cube was suggested to a United States engineer in the '70s (said to have been Gen. Meiggs) and it has remained a prime favorite with the engineers of the engineer corps ever since. It is suspended on an axis going through diagonally opposite corners. The mixing process takes advantage of one of nature's well-known laws, the tendency of materials when disturbed to consolidate and fill all voids.

It is recommended in using a cube concrete mixer that the coarser material be fed in first and that the cement go in last. As it does not mix by first separating the aggregates and then recombining them, this method of feeding in the aggregates insures that the mixing will be done in the best possible manner.

When granular materials of varying sizes are disturbed the finer material will work down into the interstices. In a cube, the corners between the corners by which the cube is suspended lie alternately on either side of the median line. As the cube revolves the aggregates move *en masse* from side to side, and this movement tends to work the finer material down into the voids. In addition to this, as the cube revolves slowly each side draws up in a thin sheet the materials that hang to it because of their weight, and when it rises to a point where the angle of repose is exceeded the material doubles over and flows down in a thin sheet over the mass below. There are six sides at different angles, and each side delivers its sheet in time to partly cover the sheet thrown over by the opposite side, and in its turn to be partly covered by a sheet from a side opposite and at another angle.

There is absolutely no throwing from side to side in a cube, thus causing severe strains on the operating mechanism. It is simply a slicing and covering of the material combined with a shaking that tends to fill the voids. How perfectly this is done can be imagined from an experiment lately made in the coloring of mortar. Some mortar was mixed in a cube and in a blade machine. In the mortar was put some coloring matter in the form of a powder. After the mortar had set the blocks were broken open. In the mortar mixed in the cube the coloring matter was distributed evenly, and no streaks could be discovered on the closest examination. The mortar mixed in the blade machines had the coloring matter distributed through it in streaks. If the mortar had been manipulated long enough in the blade machine it also might have been evenly colored. The test, however, was made to see which mixed the most efficiently in the shortest time. The batches were proportioned alike and mixed the same time in the respective machines. This test proved that the mixing action in the cube must be far superior to any mixing action imitating the shovel in a workman's hand.

The compressive strength of concrete varies from 600 pounds per square inch to as much as 4,000 pounds. Plans for reinforced concrete structures uniformly count on a working compressive strength of 500 pounds. Yet the mixing of concrete is not given nearly the importance it demands. If the concrete is mixed as too many building blocks are made there is no factor of safety. If a little more care is used a compressive strength of 1,000 pounds may be developed, and we have a factor of safety of 2. It is a safe thing to say that we are apt any day to read of disasters caused by the giving out of concrete strained far beyond its strength.

To the mixing of concrete, therefore, the engineer in charge of construction work should pay close attention. If reinforced concrete is used hand mixing is not to be considered, and if the surface of the work is to be exposed see that only the best Portland cement is used, and insist upon a close texture in the finished material. Perfect mixing accomplishes the result of getting the greatest strength to resist pressure and shock as well as to resist the moisture in the atmosphere—the greatest solvent and destructive influence in nature.

(Continued from SUPPLEMENT No. 1576, page 25247.)

VALUABLE ALLOYS.—II.

BIRMINGHAM PLATINUM.

BIRMINGHAM platinum, also called platinum-lead, is composed of copper and zinc, in proportions here given:

	I.	II.
Copper	46.5	4
Zinc	53.5	16

It is of a pure, nearly silver-white color, which remains unchanged by the air for some time. Unfortunately, it is so brittle that it can hardly be shaped in any way except by casting. Buttons are made of it by casting in metal molds which give sharp impressions, and the design is afterward brought out more clearly by careful pressing.

BATH METAL.

This alloy, on account of its fine white color, and the high degree of polish which can be imparted to it, is a favorite material in England for the manufacture of teapots. Articles made from it, if simply rubbed with a soft cloth, acquire in the course of time a permanent silvery luster. The composition is 55 parts of copper and 45 of zinc.

SOREL'S ALLOY.

This alloy has conspicuously valuable properties, which adapt it to many purposes. Its most striking characteristic is its hardness, which equals that of good wrought iron, while in tenacity it surpasses the best cast iron. In casting it is readily detached from the mold, and can be mechanically worked with great ease, but is too brittle to be rolled out into sheets or drawn into wire. It takes all the lines of the mold exceedingly well, and on this account is much used for casting small statues, which after careful bronzing are given the name of cast bronze. The large proportion of zinc contained in this alloy makes the price of production comparatively low. It is quite suitable for the manufacture of articles which are to be exposed to the influences of the weather, as it does not easily rust, and becomes covered, after a while, with a thin layer of oxide which prevents further oxidation. Two mixtures, given below, have practically the same properties, although they vary considerably in actual composition.

	I.	II.
Copper	1	10
Zinc	98	80
Iron	1	10

The iron is used in the form of cast-iron shavings, added to the zinc. The copper is then added, and the alloy kept fluid for some time, under a cover of glowing coals, in order to insure an intimate combination of the metals, without the combustion of the zinc. The combustibility of the zinc makes this method of preparation difficult, however, and it is recommended, in preparing large quantities, not to mix the metals directly, but to use brass of known composition, which is to be melted down under a cover of charcoal and slightly overheated. The zinc is then added, and finally the iron.

METALS FOR BUTTONS.

Guettier's.

	I.	II.	III.
Brass (copper 297, zinc 93)	372	372	372
Zinc	62	47	140
Tin	31	47	—

Silver colored metals of three qualities, best, medium and poor.

Other alloys are: Birmingham platinum—copper 43, zinc 57; Forbes's metal—copper 46.5, zinc 53.5; Ludenscheid button metal—copper 20, zinc 80; Bath metal—copper 18, zinc 21; Parsons's white metal—copper 55, zinc 45.

IMITATION GOLD ALLOYS.

The imitation gold alloys called, when beaten, Dutch gold, or leaf metal, are of different shades of yellow, dark, pale, or greenish, and are extensively used for cheap gold-colored coatings. The principal places where this special industry is carried on are Vienna, Nuremberg, and Fürth, and it is usually pursued in connection with the manufacture of bronze powder. The composition of these alloys varies from 77 to 85 parts of copper and 23 to 15 parts of zinc.

The metals are melted in graphite crucibles, and kept fluid for some time, in order that the alloy may become perfectly uniform. It is then cast into semicircular ingots about 23½ inches long and ¾ of an inch in diameter. These ingots are rolled cold into strips about the thickness of ordinary writing paper. Each strip is folded together so as to form a package about 23½ inches long. This is beaten under a hammer set in motion by a motor, into a ribbon about 3¾ inches wide. The very thin strips obtained in this way are cut up into pieces, which are again hammered until they begin to tear at the edges, about one thousand of them being placed together for this operation. They are then cut into square leaves, which are placed between parchment leaves and beaten under a rapidly moving hammer until they are about 5¾ inches square. Each of the leaves is now cut into four squares of equal size, which are again beaten between parchment leaves, in the same manner as genuine gold leaf, except that the process is not usually carried so far, inasmuch as this would entail too much labor and expense for a cheap material. The beaten metal is placed in books of tissue paper, which has previously been lightly rubbed with colcothar, to prevent the leaf metal from adhering. The beautiful color of leaf metal may be preserved for some time by a coating of thin varnish, colorless or pale yellow. By adding a small quantity of a pure color—aniline colors being especially good—the color of the leaf metal may be changed to red, green, violet, etc.

BELL METAL.

The composition of bell metal can be varied considerably, and the tone of the bell varies accordingly, as may be seen from the adjoined table.

	Copper.	Tin.	Zinc.	Lead.	Silver.	Iron.
Normal composition	80	20	....	....	....	....
Normal composition	78	22	....	....	....	....
Rouen alarm bell	76.1	22.3	1.6	....	1.6	....
Ziegenhain alarm bell	71.48	33.59	....	4.04	....	0.12
Darmstadt alarm bell	73.94	21.67	....	1.19	0.17	....
Reichenhall alarm bell (13th century)	80	20	....	....	....	....
Tam-tam	78.51	10.27	....	0.52	0.18	....
Japanese bells	1.10	4	1.5	....	0.5	....
Japanese bells	2.10	2.5	0.5	1.33	....	....
Japanese bells	3.10	3	1	2	0.5	....
Japanese bells	4.10	....	....	....	....	....

Small clock bells, table bells, sleigh bells, etc., require an alloy which will give a clear and pure tone. It has been learned by experience that bell metal containing about 22 per cent of tin gives the highest tone, and is therefore suited to small bells. It is an object, however, in this case, to produce the alloy as cheaply as possible by reducing the proportion of the copper, its most expensive component. The following table will show the composition of the alloys used for small bells.

	Copper.	Tin.	Zinc.	Lead.	Silver.
I.—House bells	80	20	....	....	....
II.—House bells, smaller	75	25	....	....	....
III.—German clock bells	73	24.3	2.7	....	....
IV.—Swiss clock bells	74.5	25	....	0.5	....
V.—Paris clock bells	72.0	26.56	....	....	1.44
VI.—Sleigh bells	84.5	15.42	....	....	0.1

The alloy numbered VI. contains, in addition, 0.1 per cent of antimony.

SILVER BELL METAL.

This alloy, used for small bells, has a very beautiful, silvery tone, and is nearly white in color. It is made in three varieties:

I.—Copper 40, tin 60.
II.—Copper 41.5, tin 58.5.
III.—Copper 41.7, tin 58.4.

Large bells are cast in loam molds, the design or ornamentation of the bell being given by the shape of the mold, and perfected by chasing after it has cooled. Small bells are usually cast in sand molds, though at the present time iron molds are frequently employed.

ALGIERS METAL.

This alloy cannot properly be classed with bell metal, as its composition is entirely different. It is made of copper 5 parts, tin 94.5, and antimony 0.5. The antimony is probably used only to give greater hardness. Algiers metal is nearly pure white in color, and takes a fine polish.

ORMULU (OR MOULU).

The French name for this alloy is obviously incorrect, inasmuch as it is not cast gold, but really a gold-colored bronze, related in its composition to that vari-

ety known as statuary bronze. It serves manifold purposes in industrial art, being used for statuettes and articles of ornament, as well as for candlesticks, inkstands, etc. An interesting application of it is in the manufacture of articles to be enameled. The enamel is placed in shallow cavities chiseled in the surface of the bronze, and melted by heating the latter. The edges of the cavities separate the different colors of the melted glass, and the articles, after heating, appear coated with the closely adhering enamel. This work is known by the French name of "*email cloisonné*." Cloisonné articles were first introduced into European countries from China, but at the present day the European work as far surpasses the Chinese as in the case of porcelain.

Some of the varieties of bronze which may be classed with ormulu will be given separately. They are used in the manufacture of small articles of art, an industry pursued on a very large scale in Paris and Vienna.

REAL ORMULU.

This bronze is in itself of a pure golden yellow color, and therefore requires but little gold for gilding. It is composed of copper 58.3 parts, tin 16.7, zinc 25.3, and is used for the finest bronze articles of luxury.

BRONZE FOR SMALL CASTINGS.

For the manufacture of certain articles, which are to be produced in large quantities, it is desirable to have a bronze which becomes very thinly fluid in heat, and fills out the molds well. It is customary to use cast-iron molds, and articles cast from this quality of bronze need only a slight surface chiseling to make them ready for commerce. A bronze which possesses the requisite properties in a high degree is composed of copper 94.12 parts, tin 5.88.

GOLD BRONZE.

In the case of articles where a beautiful color is desired at little expense, it would scarcely be practicable to use genuine gold for a coating; and an effort must be made to give the alloy itself a color resembling as closely as possible that of gold. A mixture which meets this requirement remarkably well is composed of copper 90.5 parts, tin 6.5, and zinc 3. Its beautiful gold color is not affected by air alone, but is quickly destroyed by exposure to air and water together. To retain the color, therefore, articles made from it may be kept standing in a room, but not exposed to the weather. Under the influence of air and moisture combined, they become covered, in the course of time, like all genuine bronzes, with the characteristic green coating known as genuine patina, highly esteemed in bronze articles for its effect in bringing out the beauty of the contours.

Another mixture called chrysochalk, also distinguished by a beautiful gold color, is composed of copper 95 parts, tin 5.

BRONZE TO BE GILDED.

Every kind of bronze can be gilded, and the gold adheres with remarkable tenacity. A striking example of this is the equestrian statue of the Emperor Marcus Aurelius, standing before the Capitol in Rome, which still shows distinct traces of the gold leaf with which it was once entirely enveloped. For castings which are afterward to be gilded, a gold-colored alloy is of course to be preferred, since, as previously observed, it will require less gold for the coating. An excellent alloy for this purpose is composed of copper 58.3 parts, tin 16.7, zinc 25.3. This is the real ormulu described before.

In many places, especially in Paris, a great deal of jewelry is made of bronze. The articles are usually made by pressing, and subsequently gilded; the bronze, therefore, must have a certain degree of ductility, and lend itself readily to gilding. The greater portion of the Parisian bronze jewelry is made of a mixture of copper 8 parts, tin 7, covered with a coating of gold of greater or less depth, according to the price, applied by the process of electro-plating.

BRONZE WHICH CAN BE ROLLED.

On account of the superiority of bronze to pure copper in point of durability under the action of sea water, many attempts have been made in the past to substitute it for the latter in the sheathing of ships; but it was long before any satisfactory results were reached, since no method of rolling out bronze was known. It was finally discovered that an alloy of the nature of bronze, composed of 100 parts of copper and from 4.5 to 7 of tin, can easily be rolled into sheets at red heat, and at the present day such bronze sheets are frequently used instead of copper for the sheathing of wooden ships.

MACHINE BRONZE.

Under this collective name may be classed a great number of alloys, of very different properties, having, in fact, nothing in common except that they are used for certain parts of machinery. Many of these mixtures—for some of them can scarcely be called bronzes—must be very hard, in order to resist wear; others must have great strength, so as not to give way under shocks or pressure, and others, again, must have the property of showing but little frictional resistance in contact with other metals, even under a heavy load. In short, the most varied characteristics are demanded in machine bronze for different purposes, and its composition must vary accordingly.

The properties of ordinary bronzes vary but little from those of other and cheaper metals, and on account of their higher price, they are seldom used in machinery, red brass being more commonly employed. The great hardness and comparative cheapness of the so-called white metal have brought it extensively into use for bearings. The white metal most frequently used in the manufacture of machinery is very rich in tin, containing in addition antimony and a small quantity of copper. Cheaper varieties are made of lead, copper, and antimony, with but a small proportion of tin.

METALS FOR BEARINGS.

The bearings of heavy axles, especially such as revolve rapidly, as, for example, the bearings of railroad wheels, are made, as a rule, from alloys which contain much copper (from 80 to 90 per cent) and which may, therefore, be classed among bronzes. Those containing the most copper have the valuable property of being malleable in heat, a property lacking in those which are poor in copper. A table is annexed, giving the composition of some of the more important varieties of the metals of this class, and the purposes for which they are especially used. It will be found, however, that nearly every large machine foundry uses a different alloy for the same purpose. This can only be explained by the difference in the quality of the metal worked. It is evident from what has previously been said with regard to the influence of small quantities of foreign metals upon the character of an alloy, that a foundry which can obtain, for instance, only copper with a content of iron, will use a different alloy from one which works pure copper.

This applies equally to all impurities present in metals; and it would mark a great advance in the technics of alloys, if we were able to procure the metals for alloys, in a chemically pure state, at a low price. The result would be that the number of alloys for each certain purpose would be lessened, and the same composition would be used in all foundries.

Metals for Bearings.

	Copper.	Zinc.	Tin.
Locomotive axles	86.0	14.0	....
Locomotive axles	82.0	8.0	10.0
Car axles	82.0	18.0	....
Car axles	84.0	16.0	....
Car axles	75.0	2.0	20.0
Various axles	73.7	2.1	14.2
Various axles (medium hard)	69.55	5.88	21.77
Various axles (hard)	82.0	2.0	16.0
Various axles (very hard)	88.8	11.2	....

Machine Metals for Various Purposes.

	Copper.	Zinc.	Tin.	Lead.
Cog wheels	91.3	8.7	....	....
Punches	83.3	16.7	....	....
Steam whistles	80.0	2.0	17.0	....
Steam whistles	81.0	2.0	16.0	....
Cocks	88.0	2.0	10.0	....
Wheel boxes (for wagons)	87.7	2.6	9.7	....
Stuffing boxes	86.2	3.6	10.2	....
Mechanical instruments	81.2	5.1	12.8	....
Files	64.4	10.0	17.6	8.6
Files	61.5	7.7	30.8	....
Weights	90.0	2.0	8.0	....
Castings to be gilded	79.1	7.8	13.1	....
Castings to be gilded	77.2	7.0	15.8	....
Piston rings	84.0	8.3	2.9	4.3
Shovels (malleable)	50.0	16.4	33.6	....
Shovels (malleable)	3.0	2.0	1.0	....
Buttons (white)	57.9	36.8	5.3	....
Sheet for pressed articles	63.88	30.55	5.55	....
Small castings	94.12	....	5.88	....
Small castings	90.0	10.0	....	....

—Translated from Krupp: Die Legierungen.

HEAT RECOVERY AND INTERMEDIATE SUPERHEATING FOR STEAM TURBINES.

IN an article by J. Nadrowski and O. Dahlke, on heat recovery and intermediate superheating for steam turbines, published in Zeitschr. Vereines Deutsch, the results obtained in the period 1903-5 with a trial plant at the Technical Hochschule, Dresden, are described. The new working system dealt with the Von Knorring-Nadrowski system, has for its object the improvement of the fuel utilization, and has been developed as a result of endeavors to introduce temperatures in the cycle higher than would be possible with piston engines—and this without artificial cooling of the exposed working part—very high temperatures, 300 to 400 deg. C., having been found admissible in steam turbines; and the remainder of the process consists in recovering as much of the rejected heat as is possible, in a regenerator, and also in reheating the steam between the different pressure-stages. Diagrams of the scheme are given, and corresponding entropy diagrams for superheats of 300 deg., 400 deg., 500 deg., and 600 deg. C. for the case of a single-stage turbine with regenerator, and for a two-stage turbine with intermediate superheating and regenerator. The course of the steam in the latter case is as follows: from boiler to superheater → first stage → second superheat → second stage → regenerator → feed-water heater → condenser. Tables are given dealing with the theoretical and actual thermal efficiency to be expected from the use of superheat with and without the regenerator, showing the considerable additional saving by the use of the latter. The practical results dealt with in Part II. confirm the view that great improvenfent in heat utilization can be expected when the temperature for the low-pressure stage is raised to 500 or 600 deg. C., which is quite capable of being borne by the superheater as the pressure is only about that of the atmosphere. A further saving is obtained by intermediate superheating yet again if more than two stages are used, even if the temperature is not over 400 deg. C. The good results in both cases are attributed to the lessened influence of the latent heat, owing to the large amount of heat imparted in superheating. The thermal efficiency of the gas engine is thereby nearly approached—in the first case owing to the high admission temperature, and in the second owing to the approximation to an isothermal expansion process at moderately high temperature. The turbine, made up of a 100-horse-power and a 50-horse-power De Laval turbine, coupled together, and to a double dynamo, was mounted direct on the boiler. Low-pressure steam could be supplied from one boiler and high-pressure or low-pressure steam from another in the wide fire-flue of which the superheater was fixed, the inner part being the high-pressure superheater, and the outer for the intermediate superheating. In Part II. full details are given of the testing methods. Tables are given of results of actual tests (1) with single-stage and low-pressure steam, (2) single-stage medium high-pressure steam, and (3) compound (two stages) with intermediate superheating. The chief figures for (1) and (2) are given below:

	(1)	(2)
Steam pressure, in atm. abs.	2.32	7.11
Temperature of steam at superheater exit, deg. C.	447	428
Temperature of steam before nozzle, deg. C.	405	409
Temperature of steam at exhaust, deg. C.	233	180
Temperature of steam before condenser, deg. C.	63	70
Steam per b.h.p.-hour, kg.	9.21	7.50
Coal (of 7,500 kg.-cals.) per b.h.p-hour, kg.	1.20	0.943
Boiler efficiency without regenerator, per cent	74.2	76.7
Boiler efficiency with regenerator, per cent	80.4	81.7
Mechanical efficiency, per cent.	53.9	46.31
Total efficiency in per cent of heat in fuel	7.07	9.0

As regards (3), tests were made (*a*) with high-pressure steam to high-pressure stage, and exhausted direct, and low-pressure steam from another boiler to low-pressure stage and condenser; and (*b*) high-pressure steam to both stages, condensing, with intermediate superheating. The steam per B.H.P.-hour for (*a*) is 6.24 kilogrammes; for (*b*), 6.86 kilogrammes. Diagrams are given showing the complete cycle and the losses at each stage for (1) and (2) above, and also for a cycle based on these results but with 16 atm. abs. pressure and 350 deg. C. before the high-pressure stage, and 1.1 atm. abs. and 500 deg. C. before the low-pressure stage. The total useful proportion of the thermal energy supplied to the grate is in the three cases, 8.7, 13, and 18.3 per cent. A table is also given which shows what can be expected from an installation working in this way. Working compound, with steam temperature 400 deg. C., 5.07 kilogrammes of steam or 0.654 kilogramme of coal (of 7,500 kg.-cals.) should be needed per B.H.P.-hour.

RAYS DUE TO OXIDATION.—Since visible radiation is produced by burning substances, it is not unreasonable to suppose that slow oxidation gives rise to some kind of radiation, and such a radiation has been discovered and studied by F. Streintz. He found that magnesium, and to a slighter extent aluminium, zinc, and cadmium, emit some form of radiation, possibly ultra-violet light, when in a gas containing oxygen; that this radiation ionizes the gas, and that it produces certain chemical effects which can be exhibited by means of photographic plates or by paper soaked in a solution of potassium iodide. Half a minute's exposure suffices to produce an image of a magnesium ring laid on a piece of KI paper. When one edge of it is supported by a plate of mica 0.5 millimeter thick, the image is blurred toward that side, showing that the rays cannot penetrate more than a few hundredths of a millimeter of air. A magnesium or aluminium condenser is discharged sooner in oxygen than in carbonic acid. If one plate of it is copper and the other magnesium, its discharge may be accelerated by charging the zinc negatively, or retarded by charging it positively. The author finds that these metals may be protected from oxidation by a positive charge, a fact which suggests important practical applications.—F. Streintz, Physikalische Zeitschrift, November 9, 1905.

THE BRAKE-SHOE PROBLEM.

THE Street Railway Journal publishes an article on the brake-shoe problem in which it points out that the cost of brake-shoes per 1,000 car-miles under present conditions is nearly double that of five to ten years ago, and is still on the increase. Attempts have been made to produce shoes of special construction intended to give greater wearing qualities without loss of efficiency in braking, and shoes of such types are largely in use. Investigation along this line was begun by the Master Car Builders' Association, and independent tests were also made by the Pennsylvania Railroad in 1892. All tests indicate that the plain cast-iron shoe is by far the most effective in producing high frictional resistance or braking qualities, composite shoes obtaining their greater wearing qualities at the expense of braking qualities. In present practice, therefore, all brake gears are designed with reference to the efficiency of cast iron as standard. Specifications are given, showing the minimum frictional qualities desirable in brake-shoes. The plain cast-iron shoe shows two distinct drawbacks, viz., rapid wearing qualities and lack of inherent strength against breakage. Under exhaustive tests the various types of shoes were found

to group themselves into three classes with respect to braking results. The first class covers the unchilled shoe, which is most efficient but least desirable on account of rapid wear. The second class embraces composite shoes with soft or hard insets, which occupy an intermediate position in braking efficiency and durability. The third class, the heavily chilled cast-iron shoes, which are the least effective in braking, although most durable. There is, however, a marked difference in their action upon the chilled-iron and the steel-tired wheels. In the master car builders' tests it was found that the shoes doing the most work were also those most affected by heat. At a certain higher train speed the retarding effects of the shoes tend to be equalized by this effect of abnormal heating; the stopping distance for a train would then be about the same with any type of shoe. This favors the use of the hard shoes for heavy passenger service in connection with the high-speed brake. A prominent source of economy appears to lie in the use of flanged brake-shoes in connection with steel or steel-tired wheels. The cast-iron shoe, however, still has the preference, strength having been added for protection against breakage by the use of steel reinforcing backs. The matter of a standard brake-head is one which should be investigated with standardization in view.

THE HISTORY OF THE MARINE TURBINE.*

FROM THE "TURBINIA" OF 1894 TO THE "CARMANIA" OF 1905.

THE recent placing of the transatlantic turbine steamer "Carmania" in commission, and the successful completion of her first voyage on December 11, make it of interest to review at this time the important work that has been done in the development of the marine steam turbine. Most of the turbines applied to the propulsion of vessels have been of the Parsons type, although some work of this character has been done both by Rateau and Curtis. In 1894 the Parsons Marine Steam Turbine Company, Limited, Wallsend-on-Tyne, England, was formed, and the experimental boat "Turbinia" constructed. Her dimensions were 100 feet long, 3 feet draft, and 44 tons displacement. She was fitted with engines of 2,000 horse-power with an expansive ratio of 150. There were three separate turbines—a high, an intermediate, and a low pressure—each driving a screw shaft, and on each shaft were keyed three propellers of small diameter. She attained a speed of over 34 knots, and in 1896 tests made by Prof. Ewing, fifteen months after the vessel was completed, showed that the turbines had lost nothing in efficiency during that interval of time.

Various other high-speed boats were built during the next five or six years which have been fully described in technical journals. Two of these, the "Viper" and "Cobra," high-speed torpedo-boat destroyers, were unfortunately lost at sea and turbine propulsion received a serious setback. An organization was finally effected, however, which included the shipbuilding firm of Messrs. Denny, the Hon. Charles A. Parsons, and Capt. John Williamson, which resulted in the first turbine steamer, "King Edward," in 1901, for service on the Clyde.

The "King Edward" is a boat 250 feet long, 30 feet beam with 6 feet draft. The arrangement of the machinery is practically the same as has been used in all the more recent vessels, including the ocean liners, fitted with Parsons turbines. There are three separate turbines driving three screw shafts. The high-pressure turbine is placed on the center shaft and the two low-pressure turbines each drive one of the outer shafts. Inside the exhaust ends of each of the latter are placed the two astern turbines which rotate as one piece with the low-pressure motors, and when in operation reverse the direction of rotation of the low-pressure motors and outside shafts.

In ordinary going ahead steam from the boilers is admitted to the high-pressure turbine, and after expanding about five times passes to the low-pressure turbines and is again expanded in them about twenty-five times, and then passes to the condensers, the total expansion ratio being about 125 as compared with from 8 to 16 usual in triple expansion reciprocating engines of the marine type. At 20 knots the speed of the center shaft is 700, and of the two outer shafts 1,000 per minute.

When maneuvering in or out of harbor the outer shafts only are used and the steam is admitted by suitable valves directly into the low-pressure motors or into the reversing motors, for going ahead or astern. The high-pressure turbine under these circumstances revolves idly, its steam admission valve being closed and its connection with the low-pressure turbines being also closed by non-return valves.

This vessel met with success on the Clyde, and her turbines are stated to have required no expenditure for maintenance and to have deteriorated in no way during five years of service. Mr. James Denny, one of her builders, estimated that the coal consumed was about 20 per cent less than if she had been fitted with reciprocating engines and paddle wheels.

In 1902 the "Queen Alexandra" was built for Clyde service. She differed from the "King Edward" in being slightly larger and in having more efficient reversing turbines. This boat formed the subject of a short report by Commander Walter F. Worthington, U. S. N., who writes as follows:

"Her owners have stated that the coal consumption is much less than that of a similar vessel fitted with triple-expansion engines, which they previously operated on the same service. The oil consumption is almost nothing, as the same oil is used over and over again; the total loss in three summers of about eighteen months' running having been but one gallon.

"The shafts, when carefully gaged, showed a wear of only 1/1000 of an inch the first summer, and nothing the second summer. The tool marks still remain in the thrust collars. Metallic packing is used for all stuffing boxes. The stopping, backing, and maneuvering of the engines were done quite as quickly and easily as could have been done with triple-expansion engines, all of the signals being answered promptly. The vacuum being constant, the speed called for was determined by the pressure shown on the gage attached to the high-pressure valve chest, so that when, at any time, the captain signaled 'half speed,' for example, he always got the same number of revolutions, and there was no delay or mistake due to attempting to count revolutions. The engines were run entirely by the pressures indicated on the gages. A dial and pointer were connected with each main engine shaft so that the direction and speed of the shaft could be observed if desired. In fact, that was the only way that one standing a short distance from the engines could know whether or not the engines were in use, as they made no noise whatever, and there was no sound of rushing steam, such as is heard in other engines."

In the London Times for December 13, 1905, is an article by Mr. Parsons upon the history of the marine turbine, from which the following statement of the more recent developments is taken in part:

"The successful results of the 'King Edward' and 'Queen Alexandra' paved the way for the long list of similar turbine vessels, the cross-Channel boats commencing with the 'Queen,' for the South-Eastern and Chatham Railway Company, plying between Dover and Calais, of which class of vessel 12 are now in service and six are building. Of these several vessels, we have the 'Queen,' carrying passengers from Dover to Calais at two knots greater speed, and with 25 per cent less coal per passenger than any other vessel on the line, while the 'Invicta' and the 'Onward' turbine boats have since been added to the fleet with results surpassing those of the Queen. Again in 1904, on the Heysham Line to Ireland, the 'Londonderry' and the 'Manxman' turbine vessels beat their sister twin-screw vessels 'Donegal' and 'Antrim,' propelled with triple expansion reciprocating engines, by one knot, and lastly, the 'Viking,' built by Messrs. Armstrong, Whitworth & Co., plying from Liverpool to the Isle of Man, has consumed during the season exactly 25 per cent less coal per knot and is nearly two knots faster than any other vessel on this line.

"About this time the third-class turbine cruiser 'Amethyst' was built for the British Admiralty. She is 360 feet in length and of 3,000 tons displacement. Three other engine-driven cruisers of the same size were built simultaneously, one of which, the 'Topaz,' was selected for a series of competitive trials with the 'Amethyst.'

"The contract speed of the vessels was 21¾ knots, and the results showed that at all speeds above 14½ knots the turbine vessel was the more economical, at 18 knots the turbine was 15 per cent more economical, at 20½ knots 31 per cent, at 22.1 knots 36 per cent, and at full power in each vessel the 'Amethyst' showed 42 per cent more power than required by contract on the coal allowed; while the 'Amethyst' reached 23.6 knots on the specified coal, and the 'Topaz' only 22.1 knots. In other words, the 'Amethyst' has a radius of action at 20 knots speed of 3,600 nautical miles, while her sister vessels with ordinary engines can only steam 2,000 miles at the same speed."

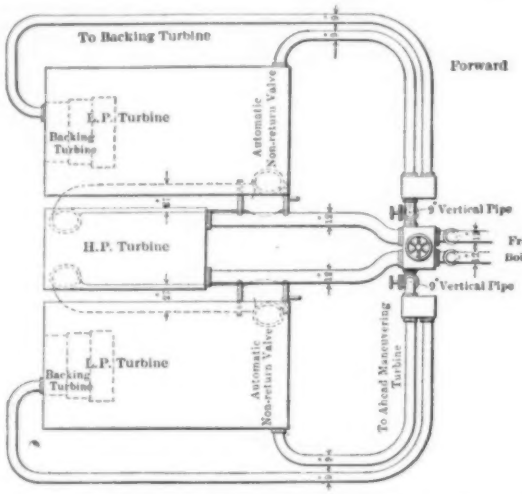


FIG. 2.—SHOWING PIPE CONNECTIONS OF TURBINES.

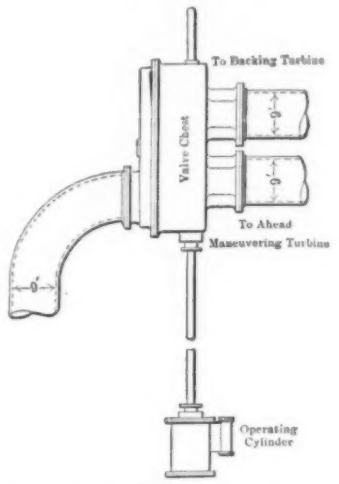


FIG. 3.—ARRANGEMENT OF OPERATING VALVE.

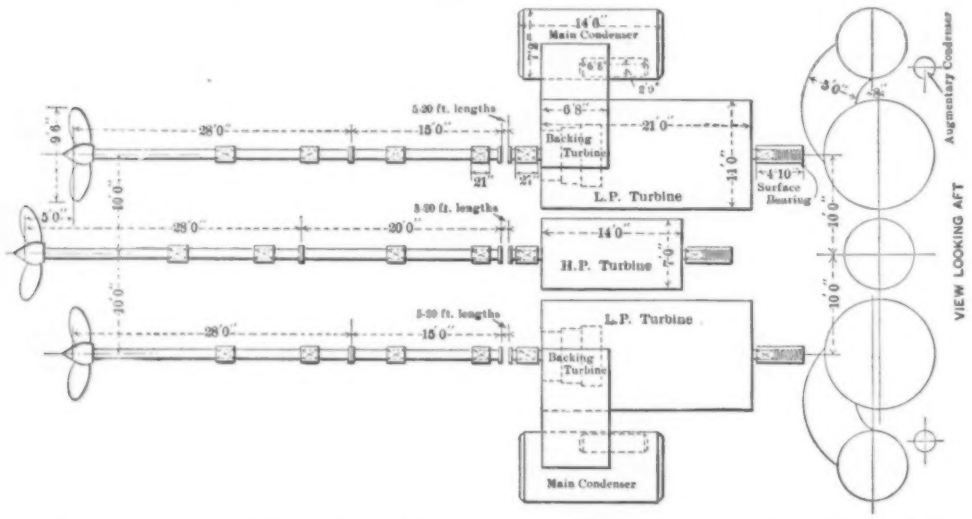


FIG. 1.—ARRANGEMENT OF TURBINE AND PROPELLERS OF THE ATLANTIC LINERS "VICTORIAN" AND "VIRGINIAN."

ATLANTIC LINERS FITTED WITH TURBINES.

Next we come to the Atlantic liners. The Allan liners "Virginian" and "Victorian" started to ply between Liverpool and Canada in the summer of 1905.

In April, 1905, Commander A. D. Canaga, U. S. N., was detailed to make the trip to Europe and return on the turbine steamer "Victorian," and report the results of his observation to the department.* There is, unfortunately, no similar vessel of the same line propelled by reciprocating engines with which a direct comparison can be made, but certain points brought out by Commander Canaga will be of interest. Figs. 1, 2 and 3 are reproduced from his report showing the arrangement of turbines in this vessel which is like that usually adopted for the Parsons apparatus, and is practically the same as already described in connection with the "King Edward." The steam from the boilers is led into the engine room through two 12-inch pipes uniting in the throttle valve at the working platform. From the throttle valve steam is led through two 12-inch pipes to the high-pressure turbine. When in free route the steam is passed through the high-pressure turbine where it spreads, half going to the starboard and half to the port turbine through the receiver pipes, and thence through exhaust pipes to the main condensers. In maneuvering, the main throttle is closed and steam admitted to the maneuvering valves, Fig. 3, one for each low-pressure turbine. These are simple slide valves which when placed at the upper end of their stroke admit live steam to the forward end of the low-pressure turbine, when at the bottom of their stroke admit live steam to the backing turbine,

* From Machinery.

* Jour. Amer. Soc. Naval Engs., August, 1904.

and when in mid-position shut the steam from both the ahead and backing turbines.

To prevent the steam blowing off into the high-pressure turbine when maneuvering, non-return valves are fitted in the receiver pipes between the high-pressure and low-pressure turbines, as shown in Fig. 2. These valves are automatic, opening or closing as the live steam is admitted to the high-pressure or low-pressure turbines.

At the forward end of each turbine shaft is fitted a safety governor which in case of accident closes the

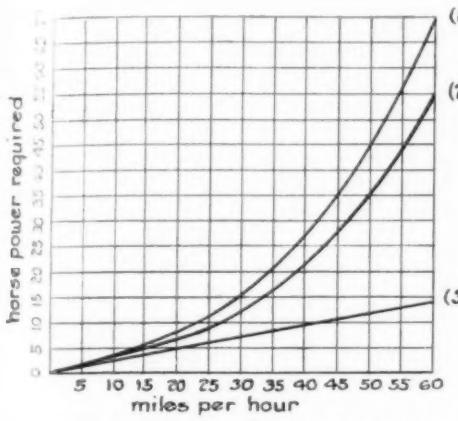


FIG. 1.—DIAGRAM SHOWING RELATION OF SPEED AND HORSE-POWER OF TOURING AUTOMOBILE ON LEVEL.

Weight of car, loaded, 3,000 pounds. Area of effective cross-section, 18 square feet. Efficiency of gears, 80 per cent.

main throttle valve. These governors serve another purpose, also, by indicating whether the turbines are at rest or in motion, since from the working platform they are the only visible moving parts. The Commander reports that the turbines are easily and quickly handled, and that the minor mishaps and annoyances met with in reciprocating engines are absent. He notes a pleasing absence of vibration and of racing in high seas. Against this immunity from racing, however, must be set the lack of holding power of the small screws with which turbine vessels must be equipped. It was observed that the influence of head winds and heavy seas reduced the vessel's speed considerably more than would have been the case with the large propellers used with reciprocating engines.

Attention is called to the fact that heating of bearings is a more serious matter with turbine machinery than with reciprocating engines, as any unusual wear would cause interference between the rotating and stationary blades. On one of the trips the "Victorian" was delayed about 29 hours owing to some grit that got into one of the bearings and necessitated overhauling, after which, however, there was no trouble. There was also considerable difficulty from priming of the boilers but with consequences less serious than in the case of reciprocating engines.

The extension of turbine propulsion to still larger Atlantic liners was a question that early engaged the attention of the Cunard Company, and a committee of investigation was appointed, composed of representatives from the Admiralty, Lloyd's, and the leading shipbuilding and engineering firms and naval architects of England, whose thorough investigation of the subject resulted in the recommendation of turbines for the large express Cunarders of 60,000 to 70,000 indicated horse-power, and also for the Cunard liner "Carmania," of 20,000 tons and 23,000 I. H. P., which has just been placed in service.

The investigations of the Cunard committee comprised comparative tests on land of large turbines driving dynamos with similar reciprocating plants at various rates of output; they also included comparative trials of the turbine vessel "Brighton" with the reciprocating-engined twin-screw vessel "Arundel" between Newhaven and Dieppe; the two vessels were run abreast, and the consumption of water taken in each vessel on both voyages, and in these trials the turbine easily beat the triple-expansion engine in economy of steaming.

COMPARISON BETWEEN TURBINES AND RECIPROCATING ENGINES.

The best opportunity for comparing the performance of vessels fitted with turbines and engines has been afforded by the Midland Railway Company's four boats of the Heysham Line mentioned above. Of these, the "Londonderry" and "Manxman" have turbines and the "Antrim" and "Donegal" reciprocating engines. The "Londonderry," "Antrim," and "Donegal" have the following dimensions: Length 330 feet, breadth 42 feet, depth 25 feet 6 inches. The "Manxman" is of the same length and depth, but has a breadth of 43 feet. The turbine boat "Londonderry" carries 150 pounds boiler pressure and the others 200 pounds pressure. The engines of the "Antrim" and "Donegal" are of the triple-expansion type, differing only in details, and drive a single, three-bladed propeller. The turbines of the "Manxman" were designed for 25 per cent more power than those of the "Londonderry," but are of similar construction and drive three three-bladed screws after the usual manner. All the boats have high-grade condensing apparatus, but the "Manxman" has in addition a Parsons vacuum augmenter, for producing a high vacuum.

The results of the official trials showed the two boats with reciprocating engines to be on a par in economy, and to use practically the same amount of feed water under like conditions. At speeds of 19 to 20 knots, however, which is the working speed of all the vessels in service, the water consumption of the turbine steamer "Londonderry" was 8 per cent less, and of the "Manxman" 14 per cent less than of the "Antrim" and "Donegal," while throughout a speed range from 1 to 20 knots the turbine boats showed superior economy. Speed trials were run between the two turbine boats and the "Antrim," and the "Londonderry" proved about one knot faster, and the "Manxman" from one to two knots faster than the "Antrim," under like conditions.

Later, comparisons were instituted between the turbine steamers and those with reciprocating engines, based on the log books in which the daily records were kept while the boats were in regular service. During a part of this comparative period the "Manxman" was not on the same route as the other vessels so that she could not be consistently compared with the "Antrim" and "Donegal" during the entire time. Also, the high-pressure turbine of the "Londonderry" was partially wrecked owing to the blades of the rotating drum coming in contact with the stationary blades so that the records from this steamer were interrupted for three months. Valuable comparative figures were secured, however, and are summarized in table below. The regular route was between Heysham and Belfast, one vessel plying each way every night except Sunday. The comparisons are made in each case between vessels running in opposite directions on the same days and the table gives the weight of coal each vessel consumed on a given number of trips, exclusive of that burned when in port, which of course does not affect the performance of the propelling machinery.

TABLE SHOWING RESULTS OBTAINED BY STEAMERS RUNNING SIMULTANEOUSLY, BUT IN OPPOSITE DIRECTIONS.

	Reciprocating Engines.	Turbines.
	Antrim.	Londonderry.
Number of Trips	48	48
Average Coal per Trip, tons	35.6	35.3
" Speed in knots	19.7	19.5
	Donegal	Londonderry.
Number of Trips	42	42
Average Coal per Trip, tons	36	36.9
" Speed in knots	19.2	19.8
	Antrim.	Manxman.
Number of Trips	29	29
Average Coal per Trip, tons	38.6	38.6
" Speed in knots	19.5	20.8
	Donegal.	Manxman.
Number of Trips	39	39
Average Coal per Trip, tons	38.7	40.2
" Speed in knots	19.3	20.3

THE UTILIZATION OF POWER IN AUTOMOBILES.*

By C. N. EDGE, B.A.

TEN years ago the maximum power of an engine placed on a racing automobile was about 4½ horse-power, and a speed of about 25 miles an hour on the level was obtained. Engines of 200 horse-power are now placed on racing cars, and even touring cars frequently have 50 horse-power.

It is exceedingly difficult to realize that these enormous powers are actually developed, and, if they are, what the retarding forces are, and what relation these forces hold to one another at various speeds.

The engine of an automobile running on the level has three distinct forces to overcome: (1) The friction of the gears, (2) the resistance of the road, and (3) the pressure of the air caused by the velocity of the car.

1. *Loss in Gears.*—The power lost at any time between the engine and the road wheels is some constant

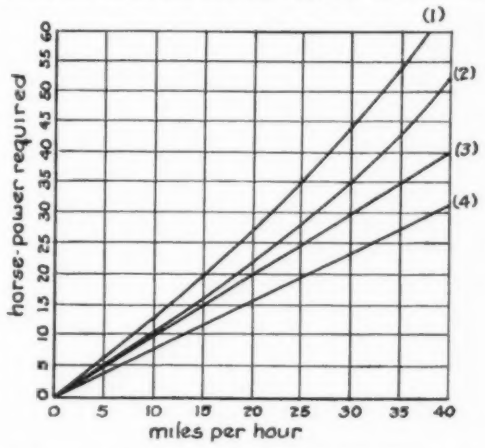


FIG. 2.—DIAGRAM SHOWING RELATION OF SPEED AND HORSE-POWER OF TOURING AUTOMOBILE UP 10 PER CENT GRADE.

Weight of car, loaded, 3,000 pounds. Area of effective cross-section, 18 square feet. Efficiency of gears, 80 per cent.

percentage of the power developed by the engine at that time. This constant proportion depends on the system of gearing, workmanship, etc. Throughout this article the gears are supposed to have an efficiency of 80 per cent, which is the best usually obtained in practice; that is to say, if an engine is developing 20 horse-power, 4 horse-power is lost in gearing and 16 horse-power only is available for actually propelling the car.

2. *Power Utilized in Overcoming Resistance of Road.*—This is proportional to the weight of the car and the velocity; and the horse-power required to overcome this resistance on a hard, level road equals 0.000076 $W V$, when W is weight of loaded car in pounds, and V is velocity in miles per hour. The constant 0.000076 was obtained from experiment on low-powered cars on which air resistance loss was at a minimum.

3. *Power Utilized in Overcoming Air Resistance.*—Horse-power required $= 0.0000106\ A\ V^3$, where V is velocity in miles per hour, and A is effective cross section of car in square feet, taken in a direction perpendicular to the direction of movement of the car. The effective area in touring cars is equal to the total area exposed in planes perpendicular to the road and crossing it at right angles; but in racing cars, where every surface is smooth and convex, the effective area may be as low as 70 per cent of the total area exposed.

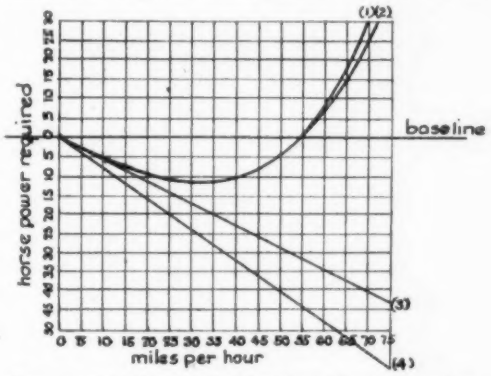


FIG. 3.—DIAGRAM SHOWING RELATION OF SPEED AND HORSE-POWER OF TOURING AUTOMOBILE ON DOWN GRADE OF 10 PER CENT.

Weight of car, loaded, 3,000 pounds. Area of effective cross section, 18 square feet. Efficiency of gears, 80 per cent.

In Fig. 1 the three losses above described have been plotted for a touring car of medium weight. The vertical height at any speed between curve No. 1 and the base line represents the total power required to drive the car at that speed. The vertical distance between (1) and (2) represents power lost in gears; between (2) and (3), power needed to overcome wind resistance; and between (3) and base line, power needed to overcome resistance of road. It will be noticed that at about 35 miles an hour the wind resistance equals the road resistance. The total power required increases very rapidly, and while at 40 miles an hour 27 horse-power is needed, at 60 miles per hour 70 horse-power is needed.

Figs. 2 and 3 show these losses plotted for the same car running respectively up and down a grade of 1 in 10. The vertical distance between (1) and the base line equals total power required; the distance between (1) and (2) equals gear loss; between (2) and (3) equals wind resistance; between (3) and (4) equals road resistance, and between (4) and the base line equals power expended against gravity by engine (Fig. 2), or power given by gravity to car (Fig. 3).

In Fig. 2 (going uphill) the wind resistance is of comparatively small moment, and the total power required is much more nearly proportional to the speed.

Fig. 3 shows the same car running down a grade of 1 in 10. The point where (1) crosses the base line

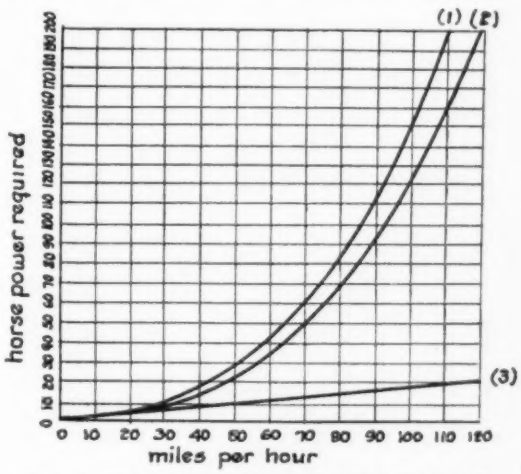


FIG. 4.—DIAGRAM SHOWING RELATION OF SPEED AND HORSE-POWER OF RACING AUTOMOBILE ON LEVEL.

Weight of car, loaded, 2,000 pounds. Area of effective cross-section, 10 square feet. Efficiency of gears, 80 per cent.

(at 55 miles per hour) is the speed at which the car would coast down hill under the force of gravity. This speed seems high and would not in practice be reached, as too long a hill would be required. Figured mathematically, a car coasting down a 10 per cent grade 820 yards in length would reach a speed of 50 miles an hour at the end of that distance in 58 seconds. It will

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

be seen that at 55 miles per hour 45 horse-power is developed by the force of gravity.

The distance below the base line of (1) in Fig. 3 at any speed, say 40 miles per hour, represents the power (10 horse-power) needed to be applied by the brakes to keep the car at that speed. It is interesting to notice that this power also occurs at 23 miles per hour, although the force retarding the car in the two cases would be different—being less at the higher speed.

Fig. 4 shows these three losses plotted for a racing car; the enormous importance of the wind resistance is immediately apparent. At 110 miles per hour this becomes 140 horse-power.

TABLE A.

Showing effective cross-section and speed on level and up and down a 10 per cent grade of different types of automobiles of a given horse-power and weight.

Type of Car.	Horse-Power.	Weight of Car, Loaded, in Pounds.	Effective Cross Section, Square Feet.	Speed on Level, in M. P. H.	Speed, Up Grade 1 in 10, in M. P. H.	Speed, Down Grade, 1 in 10, in M. P. H.
Runabout	6	1,300	13	25⅝	10⅝	50
Light touring car	10	2,000	14	38	11⅝	59
Light touring car	16	2,300	15	35	15⅝	64
Touring car	24	3,000	17	38	17⅝	69
Touring car	30	3,200	18	41¼	20⅝	71
Large touring car	40	4,000	20	45⅝	24⅛	73
Limousine body	40	4,500	25	42	24⅛	68
Racing car	60	2,000	10	70	50	92
Racing car	90	2,000	10	82	64	101
Racing car	120	2,400	10	91	74	111
Racing car	200	2,400	10	109	92	127
Racing car	200	2,400	9	115	95	132
Racing car	200	2,400	8	118	98	138

Table A.—The results given in Table A are all solutions of the cubic equation:

$$-J = 0.000076\,W\,V + \frac{4}{5} \frac{22}{15 \times 550} W \sin \theta\, V + 0.0000106\,A\,V^3$$

where J is brake horse-power of engine, V velocity in miles per hour, and θ is the angle of incline of road. The results thus theoretically obtained all agree remarkably accurately with the best results obtained in practice, and it is hoped that the formula given above may prove of some practical use, besides being of interest.

PLANTING FORESTS ON THE NATIONAL RESERVES.

Forest planting on the national forest reserves has gained far wider scope and a wholly new importance since the administration of the reserves passed to the Secretary of Agriculture, a year ago. This work now forms a leading part of the activity of the Forest Service and gives great promise for the future.

This change is due to a fuller appreciation of the needs of timber supply and water conservation and to the knowledge that nature, unaided, can not repair the forest ravage and waste of the past.

The area now under forest in the West is less by millions of acres than the area suitable for forest growth. In the first place, fire has destroyed an enormous quantity of forest, denuding mountain slopes so completely that forest renewal by natural means has been rendered impossible for ages. Again, vast areas, scores of millions of acres, like the chaparral lands of southern California, which once bore forest growth but long since lost it, must remain indefinitely unproductive wastes unless brought again, by planting, under forest. Moreover, the demand for timber, even the local demand, can not long be supplied from the reserves unless they are developed to the highest productive capacity, and, for this, forest replacement and extension, quite as much as conservative logging, are essential. Finally, the indirect use of the reserves is not less impressive. The vital importance of water for irrigation would, in the case of several of them, alone suffice to render forest planting on watersheds imperative. In southern California forest extension on the mountains is strongly favored by public sentiment, at almost any expense, because it is water, not the supply of fertile soil, which limits agriculture, so that land worth $2,000 an acre with water could hardly be given away without it.

There are now six permanent reserve planting stations—two in California, one in New Mexico, one in Colorado, one in Utah, and one in Nebraska. Others will be established as it is found advisable.

The past winter has been extremely favorable for planting in California. A large force of men has been employed, both in the San Gabriel and in the Santa Barbara mountains. Since the beginning of the rainy season about one hundred thousand seedlings have been set out. At least a dozen kinds were tried, to ascertain which are most suitable for use at different altitudes and under different exposures. Besides the seedlings set out on the mountain slopes, from two to three hundred thousand more have been transplanted from covered seed beds to open nursery beds, there to be held for use in the winter of 1906-7. The prime object of the operations in southern California is the improvement of important watersheds.

With the approach of the spring season plans are being made for active work at the other stations. The most extensive planting will be done in the Dismal River Reserve, near Halsey, Neb. Here five hundred thousand two-year-old pine seedlings will be planted in the sand hills adjoining the nursery site. This work will begin about the middle of April and will continue for a month or six weeks. This Dismal River Reserve is located in the typical sand-hill country, where the ground is of little value for agriculture, but well adapted to tree growth. The forestation of this large reserve will create an important future timber supply, and will at the same time demonstrate that these sand-hill lands generally can be put to productive use.

On the Pikes Peak Reserve planting will be done near Clyde. From thirty to forty thousand yellow pine and red fir seedlings will be shipped from Nebraska for that purpose, since seedlings in the Clyde nursery are too small for transplanting. The planting will be done on denuded watersheds for the conservation of water and for a future store of timber.

In the recently established reserve in the vicinity of Garden City, Kans., extensive experimental planting will be carried on. For this project fifty thousand pine seedlings will be shipped from Nebraska, and thirty thousand broadleaf seedlings will be purchased from nurserymen. A section of land will be fenced, and fire guards will be plowed to protect the planted area. The work here will serve the same purpose as in the Dismal River Reserve, and will, besides, be a great incentive to settlement.

The success which accompanied seed sowing in the Black Hills Reserve last spring has encouraged the Forest Service to plan similar work for this spring. Broadcast sowing had never before proved successful in reserve work, but the 300 pounds of yellow pine seed cast upon the snow in this experiment produced results far beyond all expectations, results which appear to indicate the practicability of this method on thousands of acres in this region. Of all methods of forest planting it is the simplest and cheapest, and the local demand for timber for mining purposes is great.

Nursery work will be carried on extensively at all the stations. At the Fort Bayard station, New Mexico, permanent headquarters will be established and open transplant beds constructed. With the new nursery beds at the Wasatch station, Utah, at the Bear Creek station in the Pikes Peak Reserve, and at Clyde, Col., and the enlarged beds at Halsey, Neb., the total area of seed beds will have an annual capacity of about twelve million seedlings.

At the end of the planting season nearly five hundred acres will have been newly reforested.

SOCIETY AND HUMAN EVOLUTION.

As the world's peoples and tribes were classed by race and culture jointly, it was soon seen that the types of culture really represent grades or stages in development, and also that the exercise of function and organ attending culture is a material factor in development; and hence that the course of human progress is not that of vital evolution alone, but one affected increasingly through the ages by activital forces arising in and with man himself. Like other beings of the animal realm, man is indeed a creature of birth and heredity and is influenced by environment; but through his collective activities, themselves the product and measure of culture, it becomes his chief function to modify environment and make conquest over lower nature. Even the primal factor of heredity passes partly (and increasingly) under social control; while the races occasionally blend, sometimes with so ill effect that the mixed family fades, yet often with so good result that to-day the world's peoples may be graded by ethnic complexity, the world's strongest blood being the world's most-mixed blood—and this blending reveals a law of convergent development (or intensification) extending the doctrine of polygenesis far beyond the four old-world types and suggesting that any or all of the more isolated tribes may represent primary stocks developed independently from fit local prototypes. So in the human realm the activities are paramount; and mankind may be classified either independently of or in conjunction with racial affinities in accordance with the activities and with the culture-stages defined in terms of the activities. Classified in this way, the peoples of the world fall into one or another of the four principal stages according to the degree of their advancement in some or all of the activities; and it is the special merit of this classification that it is based on and in turn becomes an index to what the peoples habitually do, and hence to their aptitude and capacity for uniting with other peoples to promote human interests and the welfare of the world. Reduced to a scheme somewhat more consistent and arbitrary than might be found in any single continent, the activities and the principal stages of their development are as follows:

Activities.	First Stage.	Second Stage.	Third Stage.	Fourth Stage.
Arts,	Mimetic,	Symbolic,	Conventionalistic,	Idealistic.
Industries,	Imitative,	Divinative,	Constructive,	Inventive.
Laws,	Maternal,	Patriarchal,	Royal,	Social.
Languages,	Demonstrative,	Descriptive,	Associative,	Reflective.
Philosophies,	Zooic,	Theurgic,	Metaphysic,	Scientific.

When the world's peoples are classified by culture-grade, or in terms of progress from the lowest to the highest stages, it at once becomes manifest that they are arranged in accordance with mentality, knowledge, and cerebral capacity, and measurably (with a few apparent exceptions) in accordance with general physical development, including strength, endurance, and viability. It is especially significant that the distinctively human attributes of mentality and knowledge characteristic of each culture-grade are essentially alike among all the peoples pertaining to that grade, however remote their homes and however diverse their physical characters; for these correspondences reveal a comprehensive law now recognized as forming one of the five cardinal principles of science: the first of these is the indestructibility of matter, established by Lavoisier; the second is the persistence of force, discovered by Rumford and Joule; the third is the uniformity of nature, demonstrated by Tyndall and Spencer; the fourth is the development of species, brought to light by Darwin, Wallace, and Huxley; the fifth is the responsivity of mind, suggested by Bacon and established by current researches in anthropology. The fundamental quality of these laws is such that the phenomena of nature (including those of the human realm) cannot be interpreted without recognizing, or at least postulating, all of them; and that no other postulates are required for the interpretation of phenomena. The last-named law summarizes observation in such wise as to show that all mankind are closely bound in a potential if not actual community of thought, sentiment, aspiration, and interest; and that, although the germ of mentality springs among the lower organisms, the psychic chasm separating man from the beasts is far wider than the physical break. Now, when the world's tribes and peoples are classified by mind and knowledge, they fall into groups, each characterized by those activital relations and motives peculiar to particular stages in the conjoint development of mental and manual processes; so that the final classification is a systematic arrangement of man and his works, both viewed in the broadest aspect and reduced to terms of works.

RECENT ADVANCES IN THE BACTERIOLOGY OF PUTREFACTION.*

By J. T. Wood.

Putrefaction may be defined as the decomposition of nitrogenous organic matter by living organisms, accompanied by the evolution of malodorous gases. The study of it may be divided into two parts—(1) the biological, (2) the chemical. The first concerns the organisms which break down the proteid molecule either directly or by means of enzymes; the second that of the different products of the action of these organisms. It is extremely difficult to separate these two studies.

Dr. Sims Woodhead (2) gives a concise account of the earliest researches on the organisms causing putrefaction of Leeuwenhoek (1692), Plenciz of Vienna, Müller of Copenhagen (1786), Needham (1749), Spellanzani (1769), Schwann (1837), Schroeder and Van Dusch (1854), Tyndall (1870), Lister (1878). These names show that the history of putrefaction proceeds parallel with the evolution of the microscope and the development of the comparatively recent science of bacteriology. I propose to-night briefly to carry it up to the present day.

I need scarcely say that putrefaction is not a specific fermentation like alcohol or acetic fermentation, but that it is extremely complex. In any putrefying matter, such as gelatin or albumin, a large number of different species of bacteria may be observed as well as monads and infusoria, and in some cases molds, all of which take part in the process. The first stage is a process of oxidation in the presence of air, in which ærobic bacteria use up the oxygen present and only simple inorganic compounds are formed, carbon dioxide, nitrates and sulphates; this part of the process is generally without odor. The second stage, or true putrefaction, takes place in the absence of oxygen by anærobic bacteria, and is a process of reduction. It has been shown that there are no bacteria in healthy tissues, and if a muscle or any organ is taken from an animal under antiseptic conditions it may be preserved indefinitely in a sterile vessel to which filtered air has free access. Solid matter is usually liquefied by organisms like B. liquefaciens magnus, which are invariably present in the air, and which prepare the way for more specifically putrefactive bacteria, such as Proteus vulgaris and B. putrificus, but if one observes a number of putrefactions of the same kind of matter under natural conditions, scarcely any two follow the same course. The modern study of putrefaction dates from Hauser, who, in 1885, isolated from putrefying flesh the three organisms—Proteus vulgaris, P. mirabilis, and P. zenkeri. He studied the action of these three in pure cultures, and came to the following conclusions:

That Bacterium termo (Ehr.) is not a single definite species; various forms and stages of other organisms have been described under this name. The various species of Proteus go through a wide range of forms during their development in which cocci, short and long rods, thread forms, vibrios, spirilli, and spirochætæ occur. Under special nutritive conditions Proteus goes through a swarm stage, in which condition it is capable of moving over the surface and in the solid gelatin. The Proteus bacteria are facultatively anærobic, they all cause putrefaction; P. vulgaris and P. mirabilis are the commonest and most active of all putrefactive bacteria. They do not secrete an unorganized ferment, but decompose albuminous bodies by direct action. They also produce a powerful poison, of which small quantities injected into animals produce septicæmia.

Tito Carbone (3) found among the products of P. vulgaris, choline, ethylenediamine, gadinine, and trimethylamine. Macé, criticising Hauser's work, considers the cocci form of Proteus to be spores. Bienstock (5) believes the rôle of the Proteus group somewhat

* Journal of the Society of Chemical Industry.

doubtful. He discovered (1884) another widely distributed putrefactive organism, which he called Bacillus putrificus; it is a spore-bearing, drumstick-shaped bacillus found in fæces; it is anærobic and specially attacks fibrin. Now, fibrin is extremely resistant to the action of most putrefactive bacteria, and it is very probable that specific organisms ferment the different albuminous compounds in the same way that the different carbohydrates are each decomposed by specific ferments. A certain number of species of bacteria are able to decompose both carbohydrates and proteids. Tissier and Martelly (13) call these mixed ferments, and divide them further into two groups: (1) Mixed proteolytic ferments, including B. perfringens, B. bifermentans sporogenes, Staphylococcus albus, Micrococcus flavus liquefaciens, Proteus vulgaris; this group decompose albumin by means of tryptic enzymes. (2) Mixed peptolytic ferments are only able to attack the albumin when it has undergone a preliminary decomposition. This group comprises B. coli, B. filiformis, Streptococcus pyogenes, Diplococcus griseus non-liquefaciens.

The second class of bacteria are those which are without action on carbohydrates, and only attack proteids; these consist of the true proteolytic bacteria B. putrificus, and B. putidus gracilis, and the peptolytic bacteria, Diplococcus magnus anærobius and Proteus zenkeri, which can only decompose peptones.

These authors state that B. putrificus is always present in putrefying albumin, but always accompanied by facultative ærobes which favor the growth and development of the special putrefactive bacteria.

In the putrefaction of meat the reaction is first acid, owing to the action of the mixed ferments on the sugars present. In the next stage ammonia ferments on the sugars present. In the next stage ammonia is formed by the tryptic enzymes secreted by the ærobic bacteria, and so the anærobic organisms are enabled to develop. We can thus understand how it is that putrefaction proceeds more rapidly the more mixed ferments there are present, although these were formerly supposed to hinder putrefaction from taking place.

When meat is exposed to air it is first attacked by the mixed ferments, Micrococcus flavus liquefaciens, Staphylococcus, Bacillus coli, Bacillus filiformis, Streptococcus, and Diplococcus, and becomes acid, at the same time the presence of decomposition products of albumin may be detected, proteoses, amidoacids, amines, and ammonia; the latter quickly neutralize the acids, and in three to four days the meat is alkaline, and has a faint putrid smell. Bacillus perfringens and Bacillus bifermentans sporogenes now make their appearance; the latter of these organisms produces amines, amidoacids and ammonia. In this stage the simple anærobic ferments are able to begin their work, and real putrefaction sets in; as this proceeds, the mixed ferments gradually disappear and finally the only organisms remaining are Bacillus putrificus, Bacillus gracilis pudidus, and Diplococcus griseus non-liquefaciens.

Another organism, which appears to play an important part in the decomposition of animal bodies, is described by Klein (6); he found that in bodies, which had been buried from three to six weeks, bacteria such as B. coli and B. proteus had almost disappeared, and an anærobic bacterium, which he calls B. cadaveris sporogenes, was very active. It is a motile bacillus 2 to 4 μ long, with flagellæ all over its surface. Spores are formed at the rounded ends, giving it a drumstick form. It coagulates milk, the clot gradually dissolving. It grows on all the usual nutritive media, but only under strictly anærobic conditions.

In a paper, entitled "Fermentation in the Leather Industry,"* I gave a short account of the progress of putrefaction as it takes place in the animal skin, and also described some of the organisms I had observed in putrefying the skin. A small piece of skin was placed in water and allowed to stand at room temperature. During the first two days there was little change, but on the third day a number of swiftly-moving darting monads made their appearance. Some of these were propelled by flagellæ, but a few had assumed amœboid forms. A slowly-moving bacillus consisting of a long straight rod, apparently broken up into cells exactly like the Vibrio subtilis, illustrated in the "Micrographic Dictionary," was observed, accompanied by some species of spirillum. Higher organisms present were a Paramœcium and a colorless transparent piece of protoplasm, shaped like a dumbbell, with a slow rotating motion. On the fifth day the number of vibrios and spirilli had greatly increased, some with a swifter motion than others. There were also many large infusoria present; one of a peculiar double form which appeared to be a development of the dumb-bell-shaped piece of protoplasm seen on the third day. On the seventh day the most striking feature was the great increase in the number of vibrios; the field of the microscope was crowded; masses of the bacilli could be seen clustered around small particles of the disintegrating skin as if feeding upon it; there were more infusoria, many of them short, boat-shaped monads, with a trembling motion, refracting light strongly; these evidently accompany the putrefaction bacteria, and assist in the final disintegration. On the ninth day the piece of skin was entirely dissolved.

Proctor calls attention to the relative putrescibility of the different constituents of skin, and especially to the rapid putrescence of the lymph and serum. So far as I know, this part of the subject has not been studied at all thoroughly, and there is a considerable field open to workers in our research laboratories.

Pure fat is not decomposed by bacteria, but if albuminous matter is present, the fat is split up by several species of bacteria and molds. Schreiber (16) has shown that the presence of oxygen is necessary. As this subject scarcely comes within the category of putrefaction, I refer you to Schreiber's paper, and also to an important paper by Otto Rahn (17) recently published.

In the putrefaction of vegetable matter the cellulose is attacked by specific organisms, which have been thoroughly investigated by Omeliansky (18). He has shown that the fermentation of cellulose is an anærobic process, caused by two species of bacteria belonging to the class of butyric ferments. Morphologically the organisms closely resemble one another, but one of them decomposes the cellulose with evolution of hydrogen, the other with evolution of methane; in both bases considerable amounts of acetic acid and normal butyric acid are produced.

The rottenness of fruit is caused mainly by different species of molds, and has recently received considerable attention on the Continent and in America. One of the principal organisms concerned is a species of Fusarium, isolated and described by Osterwalder (15) under the name of Fusarium putrefaciens. I give a list of the principal molds known to take part in putrefaction.

I have previously stated that monads and infusoria take part in the process of putrefaction, but I do not know that their action has been studied in the same way as that of bacteria. The life history and morphology of some of these monads was studied in 1871 to 1875 by Dallinger and Drysdale (19). These authors in their researches into the life history of the monads found in a putrefying infusion of cod's head, came to the conclusion that "bacteria are not the only or even (in the end) the chief organic agents of putrefaction, for most certainly in the later stages of a disintegration of dead organic matter the most active agents are a large variety of flagellate monads."

Dallinger cultivated some of the monads in Cohn's fluid and found that they lived and multiplied in it. Their spores were killed at a temperature of 250 deg. F. There is a big field of research open in this direction.

The consideration of the chemical aspect of putrefaction is a vast subject and would demand a special treatise. I shall only call your attention to one or two points of interest.

Taking the simpler bodies first, sulphureted hydrogen is formed in putrefying liquids in two ways: 1. By reduction of the sulphates in the liquid by an anærobic organism Spirillum desulfuricans. 2. By bacteria capable of growing in the presence of oxygen such as B. coli commune and B. lactis ærogenes, which ferment glucoses with formation of lævorotatory lactic acid and evolution of CO_2 and hydrogen, and if at the same time the material contains albumin or sulphur, H_2S is given off; these organisms are incapable of reducing sulphates. Beyerinck (7) has investigated this process, and found a variety of different forms intermediate between the two above mentioned, but all possessing the same characteristics so far as their chemical action is concerned, so that they may be classed as one order which he calls Aerobacter.

Stich (8) found phosphorus pentoxide in the residue from the putrefaction of casein, nuclein, lecithin and protagon, and in the putrefaction of certain organs of animals and plants gases containing phosphorus are evolved. The nucleic acid of yeast yielded phosphoric acid along with hypoxanthin and xanthin.

Vitali (9) found in the putrefaction of muscle, which had been freed from sugars and fat, that some alcohol was produced. He considers that a hexose is split off from the albumin in a similar manner to the splitting off of a fermentable sugar from the glucoproteids (compounds of simple proteins with carbohydrates). The formation of alcohol in the putrefaction of muscle occurs in the alkaline stage. Thus alcoholic fermentation is caused not alone by saccharomyces, but also by certain putrefactive bacteria.

Lermer (20) finds that the putrefaction of barley resembles butyric fermentation. An analysis of the gases given off during the later stages of the process gave the following result: Nitrogen, 58.88; hydrogen, 37.43; methane, 3.15.

In the residue from the putrefaction he found acetic, butyric and valerianic acids, but not caproic or caprilic acid. In the normal steeping process employed for barley the gases given off consisted almost entirely of carbon dioxide and nitrogen. This observation is interesting to compare with the evolution of nitrogen in the fermentation of bran shown by Wood and Willcox (this J., 1893, 422).

The action of putrefactive bacteria has been found capable of transforming hexoses into pentoses. Salkowski and Neuberg (21) inoculated a solution of *d*-glukuronic acid with putrefying meat, and showed that it was changed into *l*-xylose with evolution of CO_2 according to the following formula:

$$COH(CHOH)_4COOH = CO_2 + COH(CHOH)_3CH_2OH.$$

This is an interesting fact, especially as, according to Neuberg, the pentose contained in animal nucleoproteids is *l*-xylose.

Razor Hones.—Razor hones are often made entirely of alum. The alum is dissolved in an equal quantity of water, and the solution is evaporated. Glycerine, mercuric sublimate, and menthol are added, and the hot mixture poured into sheet metal molds. It hardens to a crystalline mass, which is ground smooth with water. The hones are best packed in metallic boxes.—Seifensieder Zeitung.

* Journal of the Society of Chemical Industry, 1894, p. 218.

SCIENCE NOTES.

By operating with about 99 grammes of ice formed from distilled water, well boiled and otherwise treated, A. Leduc finds a density that is not less than 0.9172, says Comptes Rendus, and that increases as the dissolved gases are the more removed. Though unable to get rid of all traces of gas, he concludes that the density of perfectly gas-free ice at 0 deg. is 0.9176, and that water which has been merely subjected to prolonged boiling (such as Bunsen used in his determination of the density of ice) still retains about 1 cubic centimeter of gas (reckoned under atmospheric pressure) per liter.

In fresh sewage the amount of nitrogen as free ammonia is from three to four times that of the nitrogen in the albuminoid ammonia, and in sewage effluents from twenty to thirty times, while in peaty water or water containing an infusion of leaves the nitrogen in the albuminoid ammonia is from ten to twenty times the nitrogen in free ammonia, hence when a surface water, not including rain or snow water, gives a greater amount of nitrogen as free ammonia than it does as albuminoid ammonia, the indications are that the water has certainly been polluted by sewage and that the source of the organic matter is of animal origin, and with a large amount of nitrogen as albuminoid ammonia (over twenty-five hundredths of a milligramme per liter), a ratio of the nitrogen of the free ammonia to the nitrogen of the albuminoid ammonia of less than 1 to 5 is suspicious.

What is there round the South Pole—a continent or a group of large islands? What is going on there? What thickness does ice attain? Have these regions always been glaciated, and if not, why not? Can we get any nearer the mystery of magnetism and its constant changes by study at or near the magnetic poles? All these and many other scientific questions can only be solved by general geographical research in these regions, and all interested in such questions have been delighted at the recent attempts to gain more knowledge. The object of these expeditions was frankly and purely scientific. All hope of remunerative whale or seal fisheries had been dispelled by the visit of the Norwegian whalers in 1892 to the region south of Cape Horn, and the known general condition of the land forbade any expectation of other profitable industries, unless, indeed, gold and other valuable minerals should be found, which is always possible. Beyond the fact that exploring expeditions of this character keep alive the spirit of enterprise and bring out the finest characteristics of a race—which is a point by no means to be despised—no immediate practical benefit was to be expected.

There is a vast difference in the natural fertility of soils. Some do not produce well from the start unless special attention is given to making them productive; others produce large crops for a short time and then rapidly diminish in fertility; while others, known as strong soils, remain productive for many years without attention to their fertility. But even the strongest soils will wear out in time unless they are intelligently managed. Curiously enough, as the tide of migration moved westward in this country, the settlers found soils of increasing natural fertility as they went, and in each new settlement the opinion prevailed that the soil was inexhaustible. But even the strong soils of the western prairies have now been cropped with grain and abused by improper methods of tillage until they are showing signs of approaching exhaustion. Fortunately, while the rich soils of the West were being depleted of their fertility, the development of agricultural science was going forward with rapid strides, and, while there is much yet to learn about the soil, we now know, in a general way, the steps necessary to build up and maintain soil fertility. In fact, soils that were originally only moderately productive, and that have been rendered almost sterile by improper methods of farming, can be made richer than they ever were.

We have been told by many good people that this question or that question was quite outside of the domain of science and presumptuous in one to inquire into. Astronomy and geology and chemistry are graciously permitted to be in the hands of the man of science, but life and mind phenomena are declared to be outside the province of physical science, yet the same was said about astronomy and geology and chemistry not many generations ago. Was not war made upon those who undertook to show that the earth was more than 6,000 years old, and were not the chemists who showed how organic compounds could be formed believed to be enemies of the truth and bent on misleading mankind? Isn't it curious to contemplate that those who know least about a given science should be the ones to set its limits, who know what can not be done or hoped for so much better than those who devote their lives and their best endeavors to discover what is true and what seems probable? To-day men's lives are not endangered as they used to be for their attempts to find an answer to puzzling questions, so the work goes on, and the things discovered are never like what was anticipated by the good and conservative people who know beforehand what can and what cannot be known, and it is a bit sad that the latter must die that a new generation may arise to possess the new truth. It took more than two generations to convince the world of the truth of the nebular theory, that the earth was millions of years old, that mankind had occupied the earth for hundreds of thousands of years, and the doctrine of evolution is hardly forty years old, yet are there not many who give it no credence? Perhaps one of the good things which the twentieth cen-

tury will be able to accomplish will be effectually to warn everybody of the danger of setting any limits to knowledge, also that any opinion mankind has held that has not been through the crucible of science is probably wrong, but the only reason for holding this is that so far every one so tested has been found to be erroneous.

TRADE NOTES AND FORMULÆ.

Cosmetic Raspberry Paste.—Stir together equal quantities of the best tallow (Kernfett), marrow, and lard, and add the following ingredients in their order, stirring constantly: For each 6 parts by weight of the above mixture, 4 parts of grain spirit, 2 parts of zinc white, 0.5 part of raspberry juice, 0.04 part of oil of roses, 0.1 to 0.12 part of raspberry essence (extract of raspberries with corn spirit), 0.2 part of glycerine. When a homogeneous paste has been obtained, press through a hair sieve and put into china jars.—Pharmaceutische Zeitung.

Solder for Dental Articles.—Palladium-gold, platinum-aluminium, or aluminium-gold solder is used in dental work. Copper is allowable only in very small quantities, if at all, on account of the danger of oxidation.

A good platinum-aluminium solder is made of 20 parts of aluminium, 4 parts of silver, 0.20 of platinum, and 6 of gold. A good aluminium-gold solder is made by melting 5 parts of gold, 1 of silver, 1 of copper, and 2 of aluminium. Palladium-gold solder consists of 70-90 per cent gold and 30-10 per cent of palladium, according to the desired color.—Journal der Goldschmiedekunst.

Carbide of Silicon in Metallurgy.—The steel industry first appreciated ferro-silicium, especially in the basic process. Silicon carbide containing 62 per cent of the available metal is added directly without previous heating. The action is uniform. The carbide is thus utilized for steels designed for different purposes. The absence of phosphorus and sulphur in the carbide is a decided advantage for tool steel. Smelters operating at a higher temperature than those for cast iron have been able to make use of the carbide without difficulty.—Jour. de l'Electrolysis.

Anti-friction Metal.—The following composition is a compound of this character: Copper 6 parts, tin 12 parts, lead 150 parts, antimony 30 parts, wrought iron 1 part, cast iron 1 part. For certain purposes the composition is modified as follows: Copper 16 parts, tin 40 parts, lead 120 parts, antimony 24 parts, wrought iron 1 part, cast iron 1 part. In both cases the wrought iron is cut up in small pieces, and in this state it will melt readily in fused copper and cast iron. After the mixture has been well stirred, the tin, lead, and antimony are added; these are previously melted in separate crucibles, and when mingled the whole mass is again stirred thoroughly. The product may then be run into ingots, to be employed when needed. When run into the molds the surface should be well skimmed, for in this state it oxidizes rapidly. The proportions may be varied without materially affecting the results. —Rev. des Produits Chimiques.

Attachment of Caoutchouc, Leather, Wood, Iron and Fabrics of Various Kinds.—The new Kimberlin process consists in first roughening the surfaces of the objects when possible, then applying a coat of caoutchouc or gutta-percha dissolved in one of the known solvents of these bodies, such as naphtha, benzine, carbon bisulphide, chloroform, ether, or a product derived from coal tar. It is preferable to dry these surfaces afterward, but it is not absolutely necessary. The first coat is covered with one of the known solutions capable of producing a cold vulcanization of the caoutchouc, for example sulphur chloride. When the surfaces to be fastened together are covered with the vulcanizing solution, they are placed one on another and submitted to sufficient pressure for the necessary time to produce adherence. In this way a solid attachment is secured between the different parts, and in almost all cases the objects will tear or break before they can be separated. This attachment is water-proof and may be employed in cases where other processes are not applicable.—Rev. des Produits Chimiques.

Process for Preserving Wood, Particularly Railway Ties.—M. Flamache has introduced a process designed especially for the protection of wood from the attacks of rodents and insects. It is particularly useful in hot countries. The process is based on the poisonous properties of the soluble salts of barium, or other salts of that metal which may become so under the action of acids—for instance, such as carbonic acid. When an aqueous solution is injected into wood a part of the preserving substance may be replaced by a soluble salt of barium, and this salt will remain there, either in a soluble state or precipitated, and prevent the attacks of insects and rodents. The process being based on the poisonous properties of the double salts of barium, such a soluble salt may be employed and combined with any preserving salt or be used alone. There is an advantage in making use of a mingled chloride, as chloride of zinc, in the proportion of 20 to 30 per cent and in injecting into the tie or piece of wood, with, for instance, a solution of pure zinc chloride. The wood thus prepared is claimed to be absolutely protected against the destruction referred to. On the other hand, it is evident that this process may be combined with any other, and that the wood may be coated by immersion in hot tar. The barium may also be precipitated in the wood by short immersion in a solution of carbonate of soda.—Rev. des Produits Chimiques.

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